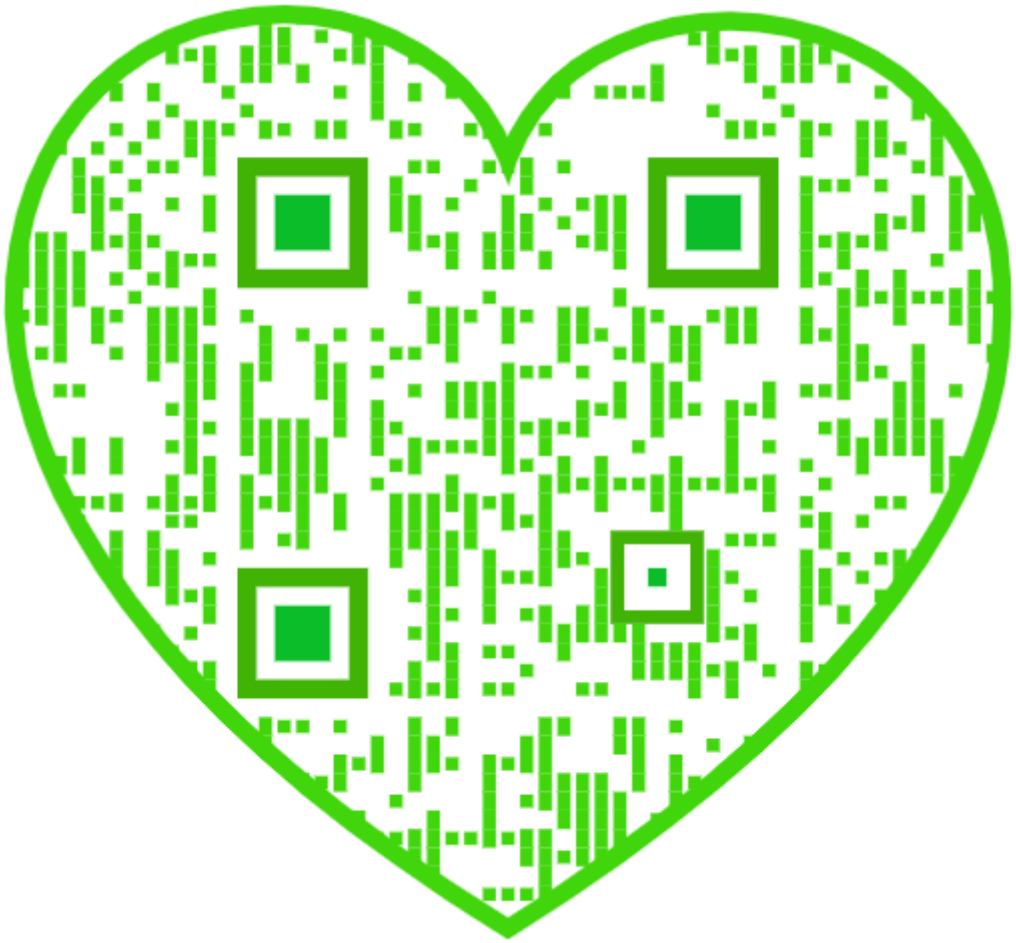
TAPPET AND DOBBY L

THEIR MECHANISM AND

THOMAS ROBER



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Tappet and Dobby Looms:

THEIR MECHANISM AND MANAGEMENT

PROPERTY OF
PEARSON ENGLISH TEXTILE SCHOOL

BY

THOMAS ROBERTS

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TECHNICAL COLLEGE

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PREFACE

THE object of this work — the greater portion of which originally appeared as a series of articles in *The Textile Manufacturer*—is to help those who are engaged in the weaving industry to obtain a fuller knowledge of the mechanism and management of the loom. At the same time it is hoped that the book will supply a much-needed addition to the scanty literature at present available on this particular branch of the manufacturing processes.

A special feature of the subject-matter is the references to defects produced in fabrics during weaving, these being drawn from observations made by the author during his many years' practical experience of the subject.

The illustrations employed to elucidate the construction of the various motions are chiefly line drawings—drawn to scale—from well-known types of looms. The detailed descriptions of the motions have been expressly included for the sake of students following out a course of technical instruction—the author, as a teacher of textile technology, having experienced a long-felt want in this particular direction.

THOMAS ROBERTS.

HUDDERSFIELD, *April* 1912.

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TAPPET AND DOBBY LOOMS

THEIR MECHANISM AND MANAGEMENT

CHAPTER I

CLASSIFICATION OF POWER-LOOMS

Looms may be divided into three classes — namely, (*a*) tappet, (*b*) dobby, and (*c*) jacquard looms. Other methods of classification are sometimes adopted—*e.g.*, according to the class of fabric for which the looms are specially adapted, as light goods tappet loom, heavy woollen loom, fancy coating box loom, and fancy cotton dobby loom; whilst they are also referred to by the name of the maker or place of manufacture. It will be evident, from the many terms of classification, that no definite line of demarcation can be drawn, although in some districts one style or class of loom preponderates. The most general method in vogue is that which differentiates according to the style of the shedding motion employed.

Tappet looms are so named by reason of the mechanism employed to control the healds. This class includes the plain loom fitted with inside tappets to take from two to eight heald shafts, or with outside tappets to accom-

modate up to twelve shafts. The latter type of loom is often styled the Bradford tappet loom, as it is largely used in that district. The plain loom fitted with the Woodcroft and other styles of tappets is also included in this class. Many tappet looms are mounted with boxes, usually circular boxes, at one or both sides. Generally speaking, such looms are employed to weave calico, plain dress goods, linings, plain coatings, serges, meltons, beavers—in short, any class of fabric which does not require a large number of healds, and in which the weave is complete on not more than 12 picks. Dobby looms are so named on account of the healds being operated by dobby mechanism, which is entirely different in its construction from tappet mechanism. Dobbies are made to accommodate 48 shafts, but 16, 24, and 36-shaft dobbies are most common. This class of loom admits of variety in weave effect, and may yield more extensive patterns than the tappet loom. It is usually mounted with a series of boxes at both sides, generally four, though for weaving certain goods six boxes are requisite; the loom may also be fitted with two warp beams. The range of fabrics produced in this loom is very wide, and includes fancy coatings, trouserings, fancy dress goods, mantle cloths, cap tweeds, mauds, and rugs. The term "jacquard looms" has reference to those looms which are mounted with a jacquard machine. The advantage of such looms, when compared with the dobby and tappet looms, is the increased figuring capacity, as the number of threads which a design may occupy is practically unlimited. Fabrics of an ornamental and elaborate character are produced in this loom, of which fancy vestings, figured dress goods, tapestries, plushes, and carpets are examples.

Installation and Arrangement of Looms.—The operation of weaving, as well as the preparatory pro-

cesses, are such that the room in which they are carried on should be well lighted. The most suitable building is a shed with a well-lighted roof, the skylights facing in a northerly direction, as a more uniform light is then assured and the direct rays of the sun eliminated. The roof should be supported by pillars, which also serve to carry the line shafts. The size of the bays is determined by the class of loom to be installed. The floor may be stone, concrete, or wood. If of wood it should be well supported by piers, these being arranged to come underneath the loom feet, a firm foundation being conducive to satisfactory results, especially if the looms run at a high speed. Some consideration is essential when arranging the looms if the most economical conditions are to be effected. The looms should be placed with their main or crank shafts at right angles to the skylights, as this admits of the light falling sideways on the loom, and consequently prevents any obstruction of light from the weaver or top rails of the loom when repairing broken ends, etc.

Right and Left Hand Looms.—To economize driving power, line shafting, and space, looms are made right and left hand; a right-hand loom is one where the driving belt is on the right-hand side of the weaver when tending the loom, whilst a left-hand loom has the driving belt on the left-hand side of the weaver. This is the generally-accepted definition, although occasionally the side on which the dobby is placed on the loom in relation to the weaver is employed as the determining factor. This is more applicable to that type of dobby loom in which the weaver, when turning the dobby to manipulate the healds, uses the right hand in a left-hand loom, the dobby being placed at the opposite end to the driving belt, and *vice versa* in the right-hand loom.

When looms are made right and left hand they may be

arranged or grouped together in various ways. A, in Fig. 1, shows the ground plan of the arrangement usually adopted with narrow tappet looms. The looms are placed in groups of four, one weaver tending each group. Looms 1, 2, 3 and 4 form one group, and looms 5, 6, 7 and 8 form another group. Each group consists of two right-hand and two left-hand looms, indicated by R and L respectively. The looms are placed with the ends of the going part close together, leaving a reasonable space between each group to form the main alley; this latter should not be too small, but sufficient space allowed to accommodate skeps and to admit the full warp beams being run in without any danger of the warps being broken. The amount of space allotted for the weavers' alley W, and also at the back of the looms, should not be too meagre. This arrangement necessitates only one line-shaft for two rows of looms. The line-shafts X, Y shown in dotted lines are overhead behind the looms, and are carried on pedestals attached to the pillars. A somewhat similar arrangement to the above is sometimes adopted for looms of a much wider reed space, with the exception that the looms are grouped in pairs, one weaver to each pair, with a main alley on each side of the loom, these being left wider by reason of the increased length of the warp beams. B, Fig. 1, illustrates a common arrangement practised in relation to looms from 9/4 reed space and upwards (one quarter equals 9in.). These looms are arranged in pairs with a main alley running down each side, and with the weavers' alley W and the back alley V continuous. The main difference between A and B is the position of the line-shafts X, Y. In the former the line-shaft is parallel with the crankshafts of the looms, in the latter it is arranged at right angles. This method admits of one weaver tending one or two looms, according to the class of work on which they are

engaged. C, Fig. 1, shows an arrangement applicable to looms in which the loom pulleys P are mounted on a

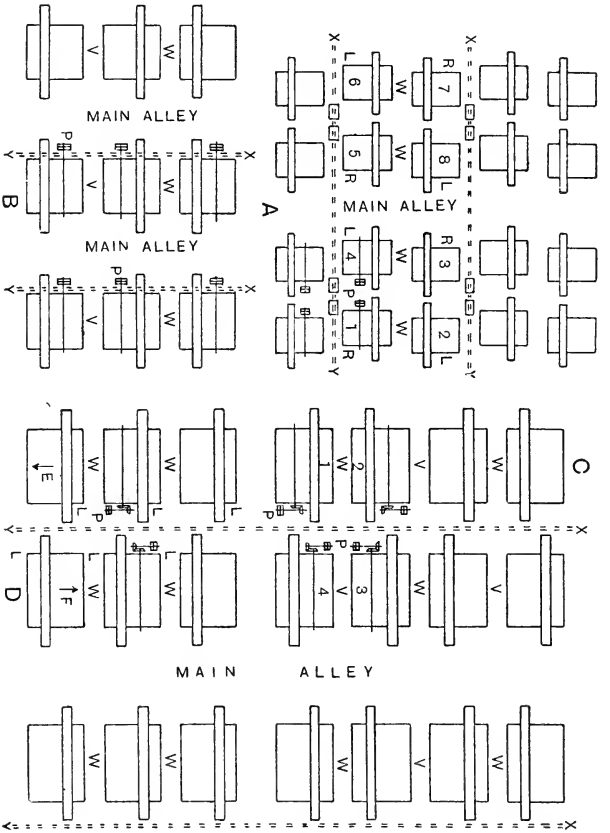

FIG. 1.

countershaft attached to the side of the loom frame, and not directly on the end of the crankshaft as at P in A and B. The looms are placed so that one line-shaft will serve

two rows of looms. This is accomplished by bringing two rows together, leaving a broad alley on each side. The line-shaft runs parallel with the countershafts of the looms. Another advantage to be derived from this arrangement is that the weaver's alley W in one row comes opposite to the back alley V of the adjoining rows. This reduces the dangers due to flying shuttles, as it will be evident that a shuttle coming out of the alley of looms Nos. 1 and 2 would travel towards the back alley of looms Nos. 3 and 4. D, Fig. 1, is an alternative arrangement to C. The looms are not arranged in pairs, but are all either left or right hand. D shows all left-hand (L); consequently one row of weavers would face in the direction indicated by arrow E, and the adjacent row in the opposite direction F. If it is desirable that the weavers should all stand in the same relative position, the looms would be arranged one row all left-hand and the other row all right-hand. The advantage claimed for this system is, that having only one weaver in each alley W there is more freedom of action, and each may render help by tying up the broken warp threads for the weaver immediately behind.

Driving of Looms.—The general method of driving power-looms is by means of belts to transmit the motion from the drums on the line-shafts to the pulleys on the loom. When the arrangement of the looms is as A, Fig. 1, two looms are driven from the same drum, and in order to avoid the belts coming together, the looms are placed so as to allow sufficient working space on the surface of the drums between the belts, the drums being made wide enough to allow for this. With one line-shaft driving two rows of looms, one row is driven by open belts and the other row by crossed belts; this is due to the looms being placed on opposite sides of the line-shaft, and the crankshafts must necessarily revolve in the

same relative direction in the looms. This is illustrated in Fig. 2, where A is a drum turning in the direction

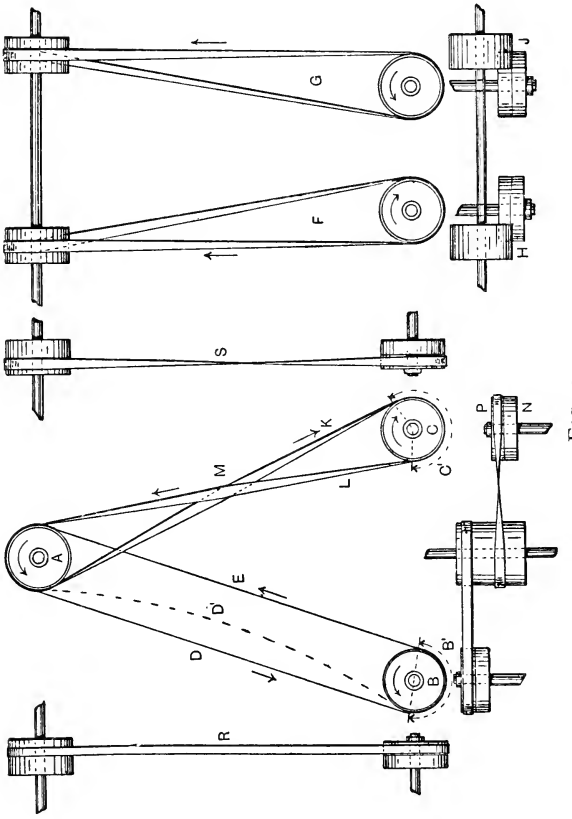

FIG. 2.

of the arrow and driving the loom pulley B and the loom pulley C by means of open and crossed belts respectively. Looms which are driven by crossed belts run up to the calculated speed much better than looms driven by open

belts. This is due to the crossed belt encircling more of the circumference of both the driving and the loom pulley than is possible with an open belt (compare B^1 with C^1, Fig. 2). The observant tuner will know that the looms driven by open belts require his attention for reduced speed and the consequent results, more than looms driven by crossed belts. The weavers are also aware of this defect, and attempt to mitigate the evil by applying resin or some other adhesive substance to the belt to prevent it from slipping. This is an objectionable practice, and should be discountenanced by the tuner, because when the grip of the belts is too excessive the loom will have a choppy movement, which is productive of more serious results—namely, defective picking, loom knocking-off, imperfect checking of the shuttle, and shuttle flying out. As further proof of this, the following experiment may be cited: The tested speed of a loom was five picks per minute less than the calculated speed; the cause of this was due to the belt slipping. In preference to tightening the belt, dressing was applied in such a quantity as would ensure no further slipping taking place; the loom now runs at the required speed. The movement of the going part was then tested by placing the hand lightly on the slay rail, when an irregular motion could be distinctly felt. Before the dressing was applied the belt was running without surging, but afterwards the maximum amount of surging took place, the surging of the belt being responsible for the erratic movement of the loom. In order to prevent excessive tensioning of a belt or the application of any dressing to maintain the calculated speed, the writer is of opinion that looms run much better if, when calculating for the dimensions of the drums, an increase of 3 to 4 per cent. in speed is allowed above what is actually required. For instance, if a loom is required to be run at the rate of 150 picks per minute, the velocity

ratio of the driving drum to the loom pulleys should work out to a calculated speed of 156 picks per minute. This method allows the belts to be run somewhat slacker, and is not attended by any severe strain on the crankshaft, or of undue bearing of the crankshaft on the pedestal in the loom. Under such conditions the belts should be kept clean, the natural state of the belt being such as will maintain the necessary friction on the drums and pulleys. Looms which are driven by open belts have the following side, which is the slack part of the belt on the top, as D, Fig. 2; and the pulling side, which is the tight part of the belt underneath, as E, Fig. 2. The advantage of this arrangement is that when the belt becomes slack it tends to occupy a position indicated by the dotted line D^1, Fig. 2, and as a consequence the contact of the belt with the drum and pulley is increased, and the liability of the belt to slip is reduced.

When looms are arranged with the driving drums at right angles to the loom pulleys, as at B, Fig. 1, the position of the loom pulleys in relation to the drums needs careful adjustment or the belts will not work to the best advantage, and a loss of speed ensues. This is due to the following side of the belt bearing too heavily on the guide-fork, and the pulling side of the belt having a tendency to leave the fast pulley. The relative position of the loom pulley to the drum is indicated at F and G, Fig. 2, of a left and right hand loom respectively. The pulling side of the belt is practically perpendicular, the approaching face of the loom pulley being in a vertical plane with the centre of the surface of the drum as H and J. The following side of the belt is conducted back on to the loom pulley by the guide-fork. The belts in such an arrangement all work at a quarter twist.

When looms are mounted with a fast-and-loose pulley driving gear, it is essential that the loom should stop as

soon as possible after it is thrown off. The relative position of the pulling and following sides of a crossed belt to each other may be arranged to facilitate this—a factor often overlooked. The following side K of the belt should cross the pulling side L as at M, as it is then free to run off the fast pulley N on to the loose pulley P without having to force its way against the tight side L, and so runs off much more quickly and easily.

When the driving motion consists of a loose and fast pulley, it is not usual to have the full width of the belt on to the fast pulley when the loom is running, but to allow a portion to remain on the loose pulley. There are two reasons for this: First, it affords means for adjusting the belt to the fast pulley in such a proportion as required to drive the loom effectively; and second, the traverse of the belt being fixed at the minimum, it runs off the fast pulley much quicker when the loom is stopped. The elongation which takes place in the belt, especially if a new one, should be noted. It is evident that the portion of the belt run on to the fast pulley to drive the loom will be stretched in a much greater degree than the portion which runs on the loose pulley only. The result of this is that the belt fails to grip the pulley, and this is attended by a reduction in the speed. To avoid this a new belt should be run in the wrong direction—*i.e.*, with the joinings in the belt against the pulleys—until it has stretched to a normal degree. It is then taken off and turned to bring the portion which has been running on the loose pulley to run on the fast pulley; each portion of the belt being subject to the same tension, a uniform grip on both the pulleys is maintained. Another method which has been occasionally adopted to prevent the belt from slipping is to have the fast pulley made slightly larger in diameter than the loose pulley—about $\frac{1}{8}$in. in a 16in. pulley.

The objectionable feature of driving by means of loose and fast pulleys is that the loom cannot be started up with the crankshaft in any position. If the crank is farther forward than the top centre, the loom must be helped by the weaver in order to attain such a speed that will ensure of the shuttle being driven across the race.

Driving Motions.—There are two classes of driving motions chiefly employed on power-looms—namely, the loose and fast pulley drive and the friction drive. Each class may be divided into two types, known as simple or direct driving and compound or indirect driving. A direct drive is one in which the driving pulley is mounted on the crankshaft, which latter receives motion directly the loom is started; the crankshaft transmitting motion to the other parts of the loom. An indirect drive is one in which the crankshaft has motion imparted to it by means of a train of wheels, usually referred to as the driving gear, the spur wheel, which is fixed to the crankshaft, being the last follower of the train.

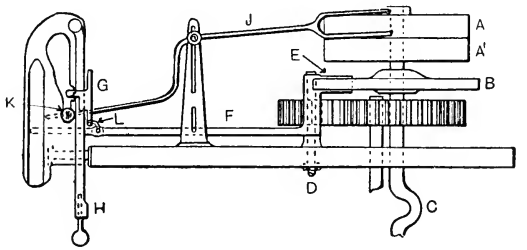

Fig. 3.

A direct driving motion is illustrated in Figs. 3 and 4, in plan and back elevation respectively. The loose and fast pulleys A and A¹ are mounted on the crankshaft C, the loose pulley being kept in position by a collar, and the fast pulley is secured to the shaft by means of a taper key

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and set-screws. The belt guide J and the starting lever K are employed to move the belt on and off the fast pulley. This is the simplest type of driving motion, and is chiefly adopted for looms which do not require excessive driving power, and is specially applicable to lightly-built looms running at a high speed. With such a drive the torsion or twisting moment to which the crankshaft is subjected when the loom is started is only slight, and the consequent possibility of breakage is considerably reduced.

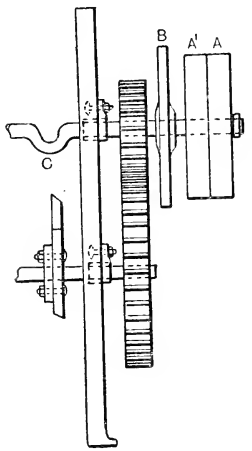


FIG. 4.

Fig. 5 shows the back elevation of an indirect driving motion. A and B are the loose and fast pulleys, C the crankshaft, D a sleeve fitted on the end of the crankshaft, E a spur driver wheel, F a spur follower wheel, G the brake wheel H the picking-shaft, J a spur driver wheel, and K a spur follower wheel. The method of gearing shows the loose and fast pulleys, the brake wheel and the spur wheel E, all mounted on the sleeve D. The spur wheels F and J are mounted on the picking-shaft H ; the spur wheel K is secured to the crankshaft. When the belt is transferred from the loose to the fast pulley, motion is transmitted to the picking-shaft by means of the sleeve D and the spur wheels E and F; the crankshaft in turn receives motion from the picking-shaft by means of the spur wheels J and K. The object attained by this indirect method of driving is to increase the eccentricity of the going part. With such a driving gear this is readily effected by having the spur wheels J and K made

slightly elliptical and eccentrically set. The purport of this is to allow more time for the shuttle to travel across the race, and to give an accelerated movement to the going part when the crank is turning the front centre and beating up the weft. When such wheels are employed the crankshaft revolves at a variable speed, whilst the speed of the sleeve D, the spur wheels E and F, and the picking-shaft H is uniform.

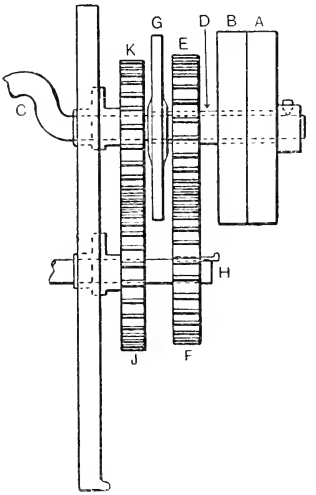


FIG. 5.

It is stated, and no doubt there is some degree of truth in the assertion, that this type of driving motion is eminently adapted for looms weaving heavily wefted goods. This is due to the acceleration in the speed of the going part occurring simultaneously with the beat-up, a much smarter blow being given to the weft, and the picks thus forced closer together. The extent of the advantage sometimes claimed on this account is probably more apparent than real. The timing of the shedding motion to the beat-up is a more important factor, and can be made to exercise greater influence in relation to the maximum amount of weft—*i.e.*,the number of picks per inch of a given count of yarn that could be put into a cloth with a specified order of weaving. Further investigation of eccentric driving reveals a defect of a somewhat serious nature. Looms to which eccentric driving is applied are invariably built with a fast reed and supplied with a

warp protector stop motion. When the loom through any cause knocks off, various parts of the loom are subject to severe shock. Knocking-off is timed to take place with the crankshaft about the top centre, and as the increase in the momentum of the going part commences with the crank in this position, the strain on the various parts will be increased in a corresponding degree; the stop motion, lay swords, and driving wheels, are thus subject to excessive concussion, and the number of breakages unduly multiplied.

The following experience in support of this statement may be of interest: It was deemed desirable to increase the speed of a certain class of 10/4 looms ten picks per minute. To facilitate this the adoption of eccentric wheels was recommended. About half the number of looms had been supplied with such wheels, when the necessary alteration in the speed of the line-shaft was accomplished. A period of unprecedented bad running of the looms at once set in, a natural outcome of the increased speed, resulting in many breakages, the most notable being the breaking of the lay swords and the stripping of the teeth in the driving wheels of those looms to which the eccentric wheels had been fitted; these defects being ultimately overcome as the looms were tuned up to the requirements of the increased speed. It is not usual to apply eccentric wheels to looms of less than 10/4 reed space, nor to all looms with a reed space of from 10 to 12/4, unless they are required to be run at the highest possible speed. The tendency at the present time is to supply concentric driving wheels to looms which have been built formerly with eccentric wheels.

Brake Motions.—In most looms an effective brake is a necessary adjunct to the driving motion, its function being to prevent the loom from over-running when thrown off. There are various types of such motions,

each being constructed according to the requirements of the loom to which it is applied. Lightly-built looms running at a high speed are supplied with a brake motion, which is only brought into operation when the loom is thrown off by the action of the weft stop motion—*i.e.*, when the weft supply fails, and in some loose reed looms by the warp protector. When the loom is stopped in the usual way by the weaver the brake remains inoperative.

This type of motion is shown in Figs. 3 and 6. The brake wheel B is keyed on to the crankshaft C outside the loom frame, and the brake lever F is pivoted on the stud D. The short arm E of lever F is the brake clog,

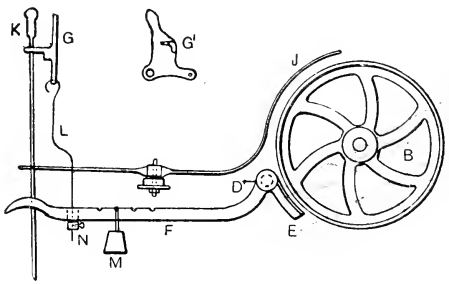


FIG. 6.

which is shod with leather to facilitate the braking action, and to prevent the working parts from wearing out too quickly. The parts for controlling the brake are the rod L and the tumbler lever G (also shown in front elevation at G¹, Fig. 6), which rests on the pistol lever H, Fig. 3. When the pistol lever H is drawn back, the starting lever K is shipped out of the retaining notch, and the tumbler lever now being without support, falls, and with it the rod L and collar N. This allows the brake clog to come in contact with the brake wheel, and

helps to bring the loom to a state of rest without undue over-running.

Careful setting of the brake is of the utmost importance. When the loom is stopped by the action of the weft stop motion the brake is applied immediately the pistol lever is drawn back, and with the belt not quite clear of the fast pulley. As a result of this the loom is liable to sudden shock and undue strain. This may be modified by fixing the collar N on the rod L in such a position that it will keep the brake clear when the loom is running, and when the loom is thrown off to allow as long a drop as possible before the brake is applied. The weight M should be adjusted on the lever in such a position that it will render the action of the brake as gentle as possible, stopping the loom with the crank on the back centre and the shuttle at the shuttling side of the loom.

Another type of brake motion is shown in Fig. 7, and is somewhat similar to that already described. This is applied to fast reed looms, and differs from the former type in the following particular—namely, that the brake is applied to reduce vibration when the loom knocks off. The brake B is actuated by means of the dagger D, on the stop rod E, engaging with the frog F, which is attached to the brake lever C. When the frog is forced forward by the impact, the brake is drawn in contact with the brake wheel A. When the brake is actuated from the frog it should be set so that contact with the brake is made before the full force of the impact takes place, but not until the belt is running off the fast pulley.

When knocking-off occurs, the starting lever J is shipped out of the retaining notch by the projection K, on the frog F, coming in contact with the T-bolt L, which is bolted to the starting lever. The brake clog should be adjusted to the wheel so that it makes contact on the

entire braking surface of the clog, and the parts should be kept free from grease.

Another feature of this brake motion is the provision which is made to enable the weaver to operate the brake. This is effected by extending the lever G, to be easily accessible to the hand or knee. The spring H, placed on the rod M, between the collar and the brake lever,

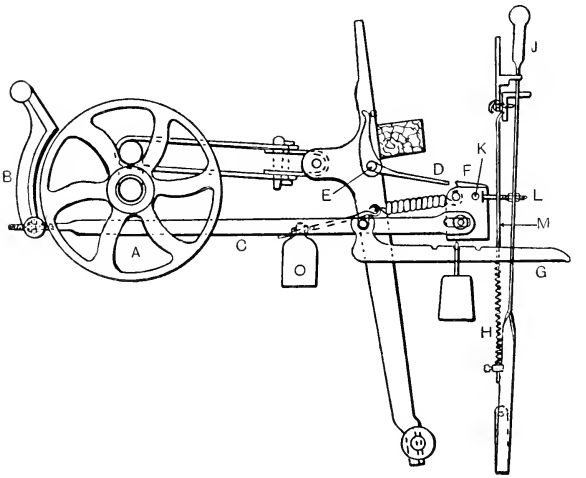


FIG. 7.

permits of the brake being applied with the pistol lever in position.

BALANCE WHEEL.—A balance or hand wheel is usually fixed on to the end of the crankshaft as an appendage to the driving motion; this enables the weaver or tuner to manipulate the loom by hand when necessary. A minor advantage in the form of kinetic energy is also derived from this wheel, which assists, although in a small degree, to overcome the variable resistance encountered by the

driving motion in turning the crankshaft one revolution. If the weight of this wheel and the consequent amount of accumulative work were too excessive, more effective braking power would be required.

FRICTION DRIVING.—This class of driving motion may be either direct or indirect as previously defined in this chapter. It differs from the former described type of driving motion in the following particular—namely, a friction clutch is substituted for the loose and fast pulleys. The clutch consists of a loose pulley on to which the belt is continually running; the pulley is made with the under side of the rim cone-shaped. Working in conjunction with the loose pulley is a disc, the rim of which is also cone-shaped to coincide with the rim of the loose pulley. To facilitate frictional contact the rim of the disc is clothed with leather. By this means the grip may be increased, as the pulley and disc may then be forced into closer contact than would otherwise be possible. When the leather wears out it may be readily replaced; whereas if the disc through any cause is allowed to wear down, additional expense will be involved.

There are two methods employed in order to obtain the necessary contact between the loose pulley and the disc: (*a*) The loose pulley may be placed under the control of the starting lever, and when the loom is started the pulley is pushed forward on to the disc, which is firmly fixed to the shaft; (*b*) the disc may be controlled by the starting lever. The disc in this instance is mounted on a feather key, which prevents the disc from rotating on the shaft, but is capable of being actuated in a lateral direction, and placed in contact with the loose pulley.

The former of these two methods gives the most satisfactory result. This is due to the disc being securely fixed to the shaft, and therefore resists the sudden strain

much more effectively. In the latter method, the disc being movable, the minimum amount of clearance must of necessity be allowed between the key and the keyway of the disc. As the key and keyway gradually wear down, the clearance increases, and an amount of backlash takes place when the loom is started. The result of this is that the key and keyway in the disc are liable to be bruised, and as a consequence the disc will be obstructed in its movement to and from the loose pulley.

An indirect type of a friction driving motion is illustrated in Fig. 8. The loose pulley A, shown in section for the sake of clearness, is mounted on the countershaft B, to which is also secured the friction disc C by means of a taper key and a taper pin. At the other end of the countershaft the bevel wheel D is fixed by means of saddle key and lock-nuts E. This wheel is in gear with the bevel wheel F, which is keyed fast to the picking-shaft. Directly behind F, and fixed to it by means of the studs H, is the spur driver wheel J, this in turn being in gear with the spur follower wheel K, which is secured to the crankshaft L.

When the loom is set in motion, the loose pulley A is actuated from the starting lever M through the bracket N and the rods O and P, and the lever Q. The lever Q is constructed to span the two projections, one on each side of the loose collar R fitted to the boss of the loose pulley. The action when the loom is set in motion is to force the pulley forward on to the disc—*i.e.*, in the direction of A^1. When contact is made the motion is conveyed through the countershaft and the train of wheels, to the picking and the crank shafts.

Features and Advantages of this Indirect Driving Motion.—This type of driving motion possesses several noticeable features: (1) A ready method is pro-

vided to adjust the loose pulley to the disc as occasion requires, when the leather is worn down. This is obtained by regulating the length of the rod P by means

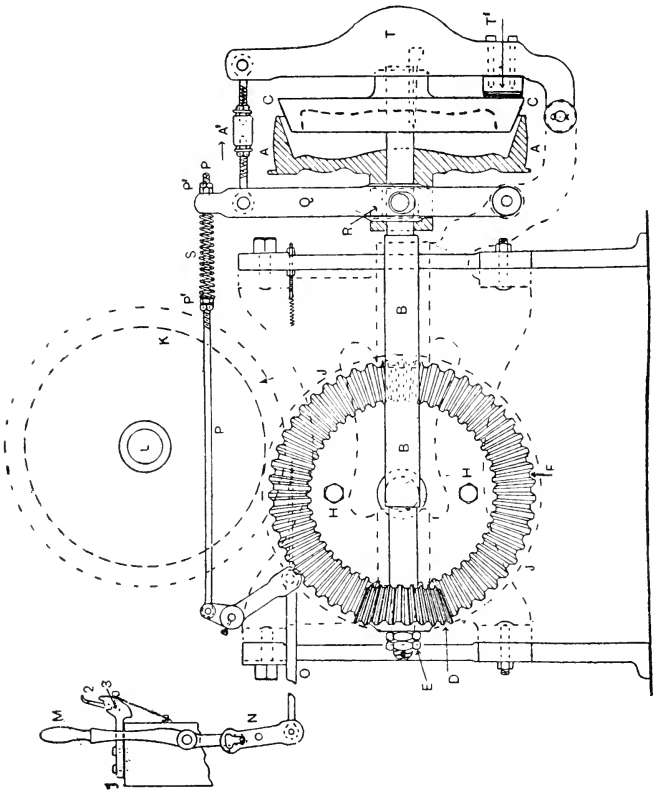


FIG. 8.

of the nuts P¹. The spring S serves as an escape motion for any discrepancy that may be due to error in setting the movement of the pulley. (2) The bevel wheel D is a change wheel, and is usually supplied with the loom in

three sizes. The substitution of one or other of these wheels effects a difference in the speed of the loom to the extent of 20 per cent.—*i.e.*, a loom running at the rate of 95 picks per minute with the medium wheel could be reduced to 90 picks or increased to 100 picks per minute. The necessary changes can be made in a comparatively short time, with the line-shaft running, no alteration in the length of the belt being necessary. This is extremely useful in some branches of the weaving industry, as when weaving certain classes of goods the production per loom may be increased by a reduction in the speed. (3) The construction of this type of driving motion is such that eccentric or concentric wheels may be adopted. (4) This indirect method of driving necessitates the line-shaft being run at a much higher speed than if driven direct. By reason of the increased speed the undesirable effect on the running of the loom, due to any irregularity in the speed of the line-shaft, is minimised—*e.g.*, assuming that a loom is driven direct, and is required to be run at the rate of 90 picks per minute, the loom pulley is 14in. diameter and the drum on the line-shaft 25in. diameter. The speed of the line-shaft must equal $\frac{90 \times 14}{25}$ $= 50\frac{2}{5}$ revs. per minute; or if the drum on the line-shaft is 15in. diameter, then $\frac{90 \times 14}{15} = 84$ revs. per minute. Again, taking the above example, but with indirect driving, as shown in Fig. 8, full particulars being as follows: Size of driving drum 25in. diameter, loom pulley 14in. diameter, number of teeth in bevel D 18, bevel wheel F on the low shaft 54 teeth, the spur driver and spur follower wheels J and K 36 teeth each. Working in stages the speed of the countershaft must equal $\frac{90 \times 36 \times 54}{36 \times 18} = 270$ revs. per minute. The speed of the

line-shaft to give this speed will be as follows: $\frac{270 \times 14}{25}$ $= 151\frac{1}{5}$ revs. of line-shaft, showing the velocity ratio of the indirect drive to the direct drive: (*a*) With 25in. drum in each case, as $151\frac{1}{5} : 50\frac{2}{5}$; (*b*) with 25in. drum and 15in. drum respectively, as $151\frac{1}{3} : 84$; the velocity ratio of the countershaft to the crankshaft of the loom being in the proportion of 270 : 90 revs. per minute—*i.e.*, 3 : 1.

This type of driving motion is adopted on many different builds of looms in some modified form—*e.g.*, the type of motion illustrated in Fig. 8 may be supplied with loose and fast pulleys in place of the friction clutch. In other looms the countershaft is placed so that the bevel driver wheel will be in gear with a bevel follower wheel fixed to the crankshaft of the loom, and not the picking-shaft as shown in Fig. 8.

Friction driving is usually applied to looms of a heavy build, to which it is eminently suitable. With friction driving the full power is transmitted to the loom directly it is started. The loom attaining full speed immediately, the liability to knock-off, as is the case with loose and fast pulley driving, is reduced. A much more effective drive is also obtained, by reason of the full width of the belt being utilised to drive the loom. The disadvantage encountered with this type of driving motion is that owing to the instantaneous action the parts are subject to excessive strain, and consequently attended with greater expense in repairs. The strength of the shaft and clutch should be such as adequately to resist the strain applied. The boss of the loose pulley should have as much bearing surface on the shaft as possible. This keeps the pulley in truth with the disc much longer, as when the loose pulley or the shaft is worn down the action of the belt on the pulley is to throw it out of truth; then when the loom is started the disc is worn down at one

part of the circumference before making full contact. A defect common to friction driving is when the pulley is not pressed tightly on to the disc, or when oil is allowed to fall on to the leather, the result being unsteady running and reduced speed. In all indirect driving motions a slight loss of power is inevitable with the train of wheels, but this may be reduced by having the wheels machine-cut.

Brake Motion.—An alternative type of brake motion to those already described is also shown in Fig. 8. The brake in this instance is applied each time the loom is thrown off. The brake lever T is controlled from the lever Q which actuates the loose pulley. The brake clog T^1 is secured to the lever T in such a position as to bear on the side surface of the disc when the loom is thrown off. When the loom is started the brake clog is pushed clear of the disc by reason of the reciprocating action of the lever Q and the brake lever T. With such a brake motion some considerable difficulty is experienced whenever it is desired to manipulate the loom by hand, due to the action of the brake on the disc. It is not always advisable to move the loom by means of the belt when repairs are being executed, as a certain amount of risk would be involved on this account. To overcome this a brake easing motion is supplied. This is shown at the upper left side of Fig. 8, this part of the diagram being drawn to half the scale of the other portion. Secured to the loom frame on a level with the breast beam is a bracket 1 carrying the lever 2 pivoted on the stud 3. The lever is made such a length that when drawn downwards it comes in contact with the shipper handle M, forcing it slightly forward, the result being that the brake clog is pushed clear of the disc. The amount of movement at this point requires careful and accurate adjustment; otherwise the loose pulley may engage with the disc and so move the loom at intervals.

SPEED AND PRODUCTION.—The ultimate object in power-loom weaving is necessarily to obtain the maximum production. There are factors which exercise considerable influence in this direction. The speed of the loom is no doubt of primary importance. Obviously an essential feature in loom driving is to have uniform running of the line-shaft, a factor not always in evidence. This is due in some instances to the fact that many looms are to be found installed in rooms altogether unsuitable, which were not originally intended to accommodate power-looms, and the motive power is not equal to the requirements. In other instances numbers of looms could be found driven from line-shafts which are turned by the same engine that is employed to drive other heavy machinery. When the reactionary nature of loom driving is added to the above, the unsatisfactory results in the speed and economical running of the looms are readily explained. These undesirable results are now happily a diminishing quantity, special attention being paid to the above in the modern weaving establishment. Generally speaking the speed of the loom is governed by the type of loom and the class of fabric on which it is engaged. When tender yarns are employed as either warp or weft, and the loom run at the same speed as for good elastic yarn, the time occupied by the weaver repairing the increased number of breakages would quickly counteract the advantage accruing from the high speed. To this should be added the increased cost of mending the pieces, the waste of material, and the decrease in production.

Another matter of primary importance is the preparation of the yarns for the loom. If in the warping process ends have been allowed to run down and imperfect knots tied, or if sizing has not been done successfully or beaming performed in a slipshod fashion; and if in the

preparation of the weft yarns, the twist, winding, size and shape of the cops are faulty—any or all of these defects will diminish the output. The practical tuner will readily detect any of these or other irregularities, and should immediately report the same to prevent as far as possible any repetition. The extent to which the preparatory processes may or may not be conducive to the maximum output, is of such importance as to demand considerably more attention than is usually given to them. While the above-mentioned points are of sufficient importance to merit the attention of those concerned, the premier responsibility undoubtedly rests with the tuner.

The duty of the tuner is to keep the looms in good running order, and produce the maximum output consistent with economy. A factor of importance in this direction rests in a judicious selection of the work to be put into the various looms, it being a well-known fact with the practical tuner that one loom would weave a difficult piece much better than another loom. In many weaving sheds the work is portioned out for the looms by one known as the " putter-up." This position is not always filled by one who is in possession of practical experience in so far as the possibilities of the loom are concerned. The result of this is that the work is portioned out irrespective of its suitability or otherwise for any particular loom. Therefore the tuner should be allowed to exercise his practical experience in the selection of the work to be put into the looms under his care.

SPEED CALCULATIONS.—The following formula may be employed to ascertain the speed of shafts, size of drum and change wheels required:—

Formula: $D\ R = d\ r$;

where D = diameter of the first driver or product of all drivers; R = number of revolutions per minute of the first driver; d = diameter of the first follower or product

of all followers; r = number of revolutions per minute of the last follower.

Taking the calculation as given above, it is required to find the speed of the line-shaft to run the loom at the rate of 90 picks per minute.

By formula: $D R = d r$;

i.e.,

$$D \times R = d \times r$$

$$\overbrace{25 \times 18 \times 36} \times x = \overbrace{14 \times 54 \times 36} \times 90.$$

$$\therefore x = \frac{14 \times 54 \times 36 \times 90}{25 \times 18 \times 36} = 151\tfrac{1}{3} \text{ revs., speed of line-shaft.}$$

Or if it is required to find size of drum on the line-shaft—

$$D R = d r.$$

$$x \times 18 \times 36 \times 151\tfrac{1}{3} = 14 \times 54 \times 36 \times 90.$$

$$\therefore x = \frac{14 \times 54 \times 36 \times 90}{18 \times 36 \times 151\frac{1}{3}} = 25 \text{in. size of drum.}$$

Or if it is required to find the number of teeth in the bevel change wheel—

$$D R = d r.$$

$$25 \times x \times 36 \times 151\tfrac{1}{3} = 14 \times 54 \times 36 \times 90.$$

$$\therefore x = \frac{14 \times 54 \times 36 \times 90}{25 \times 36 \times 151\frac{1}{3}} = 18 \text{ teeth.}$$

And similarly when it is required to find any one of the remaining factors.

N.B.—The factors 36 on each side of the equation may be omitted.

Transmitting Motion Throughout the Loom.—It will be evident from what has been already stated concerning the driving motion that its function is to impart motion to the primary shafts—*i.e.*, the crank and low shafts. From these, motion is then conveyed either directly or indirectly to the remaining parts of the loom.

There are numerous principles exemplified and employed in order to perform the several motions required in power-loom weaving—*e.g.*, (1) Spur and bevel wheel gearing; (2) worm and worm-wheel gearing; (3) ratchet wheel and pawl. These principles illustrate both continuous and intermittent motions, of which the method of driving the tappets in tappet looms, and the dobby in some dobby looms, are examples of the continuous motion; whilst the picking and box motions on all looms are illustrative of the intermittent motion. In addition to the above principles there is another of equal importance—viz., the principle of levers, examples of which are to be found in the mechanism of all box motions. In view of the above remarks it will appear as though the tuner must possess a general knowledge of mechanics. This is the opinion of the writer, who, from observation and actual experience, does not hesitate to say that the more efficient the tuner is in the study of mechanics the more successful will he be as a tuner. That there are successful tuners who have never had any special training in theoretical or applied mechanics is a fact not to be gainsaid, but such have only arrived at their present state of efficiency after many years of practical acquaintance with the loom; and such experience could probably have been acquired by much less laborious work had they possessed some knowledge of the subject referred to. It is not the intention nor wish to incur the resentment of any tuner, but merely to point out that some acquaintance and knowledge of applied mechanics and kindred subjects is well worth acquiring. That such knowledge would not only prove helpful but would also yield additional interest in the work is readily admitted. One fact in support of this contention is that the man of "rule-of-thumb" methods is being superseded by the more advanced and technically-trained workman.

CHAPTER II

MOTIONS OF THE LOOM

THE several motions in power-loom weaving are usually divided (by the theorist) into the following:—Primary motions: Shedding, picking and beating-up. Secondary motions: Letting-off the warp and setting-up. Auxilary motions: Box motion, weft stop motion, etc. Proceeding to discuss the several motions, it is only a minor matter in which order they are dealt with.

BEATING-UP MOTION.—This is no doubt the one motion of the three primaries that could be discussed at considerable length from a theoretical standpoint. However, it is from the practical point of view that it must be approached. The object of this motion is to control the going part or lay of the loom. The going part serves the dual purpose of beating-up the weft when in its front position, and provides a ready medium when in the back position, on which the shuttle may travel from box to box. Fig. 9 illustrates, in side elevation, the most generally adopted method of actuating the going part of the loom. The lay A consists of a beam of wood which, in plain one-shuttle looms, is extended to such a length as to allow the shuttle-boxes being built upon it. When the loom is supplied with a number of boxes at one or both ends, then the lay only extends to within half-an-inch of the shuttle-boxes. The lay is supported on the lay swords B, these being usually constructed with a projecting arm, to which the lay

is firmly bolted to ensure absolute rigidity. The lay sword is centred on the rocking shaft C, which in some looms is a short shaft, but in others it extends from one lay sword to the other. Motion is conveyed to the going part from the crank D by means of the connecting arm E, this being secured at one end to the crank and at the other end to the connector pin F.

CONSTRUCTION OF THE GOING PART.—An observation of the cross-section of several going parts shows that the method of construction has been to obtain such conditions of strength as will effectively resist the excessive strain to which they are subject. Some are made in one solid piece, with a groove cut in the upper portion to accommodate the bottom rib of the slay. Directly behind the groove an iron plate is secured, $\frac{3}{8}$in. thick and 2in. deep, which is carried the full width of the reed space for the purpose of giving additional strength. In some looms an angle plate is used, this being secured to the back and bottom of the lay. Another method adopted on some box looms is to construct the lay of two battens, running in the direction of the reed; the back portion is grooved to admit the lower rib of the slay, and only extends to the shuttle-box. The front portion is carried forward, and assists in supporting the framework of the boxes, of which it may be said to form a part. This type possesses an advantage over the former, because it prevents to some extent the possibility of the wood warping if it is not properly seasoned.

Another type is shown in Fig. 9. Here the portion shaded at G represents the metal of the projecting arm on the lay sword, which extends some 16in. along the lay. To accommodate the lower rib of the reed a portion of the batten is cut away, the groove being formed by the separate lath H, to which is screwed the iron plate T. To grip the reed the lath H is drawn forward and held

firmly in position by means of the bolts J, which pass through the lay and are tapped into the plate T. The reed in each case is kept in position at the top by the slay-cap K; this may be made of iron or of wood, strengthened by the addition of an iron plate.

To the top of the lay on which the shuttle travels it is usual to provide a special race. This in some looms is made of wood; in others it takes the form of a steel plate. Of these two types the following advantage is claimed for the former—namely, that the warp threads are not so readily cut by the shuttle passing over them. When the boxes are out of truth, or the picking faulty, the shuttle may be thrown down on to the race, as it leaves the box, with such force that the threads are chopped. This is more prevalent when weaving fine warps, and to obviate this the following method is sometimes practised. The race is covered with cloth, piece ends being used for this purpose. The cloth is first tacked to the front of the lay, then folded back over the race and laid over the groove, into which it is pressed and held tightly in position by the reed. A little extra pick is required under these circumstances, due to additional frictional resistance, but warps of fine counts, and those with a small number of ends per inch, have been made to weave much better by the adoption of this method, the cloth forming a sort of cushion for the warp. The objectionable feature of the wood race is that small grooves are cut into it if the shed is boarding too heavily, and especially when weaving coarse warps, the result being that any knots coming up in the warp catch in the grooves and are broken.

Movement of the Going Part and Flying Shuttle.—It is of the utmost importance that the going part works in absolute truth. The nature of the movement imparted to the lay is such that the shuttle should have every point in its favour during its passage across from

box to box. The movement of the lay is not conducive to the desired result, this being due to the following cir-

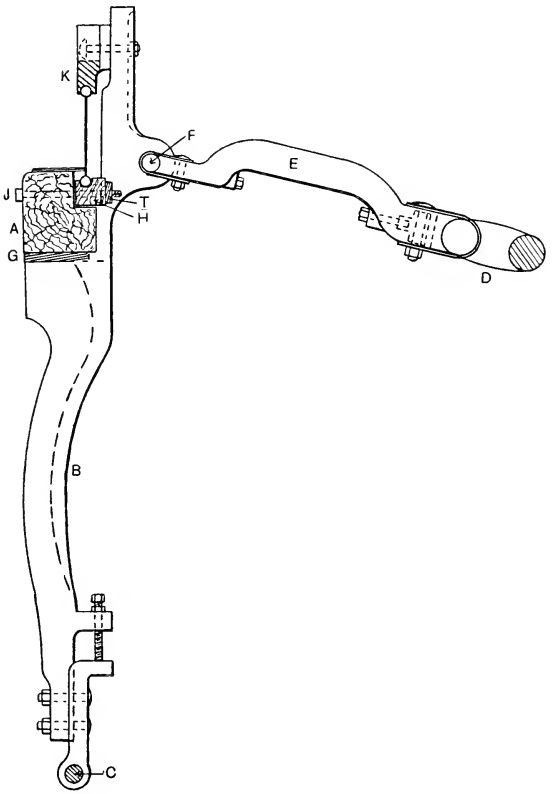


FIG. 9.

cumstances:—The lay first begins to move backward, then remains stationary for a short period, while the crank is turning the back centre, and then begins to come forward. When to this variable movement we

add other possible discrepancies, the importance of a true race is apparent. One of the many causes of " flying shuttles " is the lay being out of truth, and this defect may be traced to some of the following:—(*a*) The angle formed by the race-board and the slay not being exactly the same as the bevel of the shuttle; (*b*) the slay and back of the shuttle-box not being in alignment; (*c*) the race and bottom of the shuttle-box being out of truth, and especially in box looms. Whenever the shuttle begins to work unsatisfactorily the race should be tested. This is usually done by means of a straight-edge, which is first placed at the entrance of the shuttle-box, testing the slay with the back of the box, then the race with the bottom of the box; if a box loom, each box should be tested. The straight-edge is next run across the reed, as it sometimes happens that this is found to be defective. This may be due to a bulge in the reed, or to some hard substance accidentally getting into the groove before putting in the reed when starting the loom. Healding hook, slay knife, and brooches have sometimes been the source of trouble. Should this simple test fail, then a more exhaustive one should be made, assuming, of course, that the race is at fault. This may be done by testing the angle formed by the race and slay across the lay, then testing by means of a plumb-line stretched tightly across the lay from the back of the shuttle-boxes, and comparing extreme and corresponding measurements.

Another defect productive of serious results is due to the going part not working square throughout its stroke. This is brought about by reason of the connecting arms being packed, to avoid too much chase and consequent erratic movement of the going part, when beating-up and picking take place. The packing of the arms being necessary when the bushes have become very much worn,

this defect is often brought about by unequal packing. A similar defect will be set up if the positions of the rocking shafts are not identical with each other. In each instance the reed would not meet the cloth squarely, and if in a loom provided with a warp protector, the protector blade would not strike the frogs at the same time, proving a fruitful source of unnecessary breakages. In looms where an additional connecting arm is employed to connect the shuttle-box end to the stud in the balance wheel, the arm should be set with the greatest accuracy, otherwise the box will work on the twist.

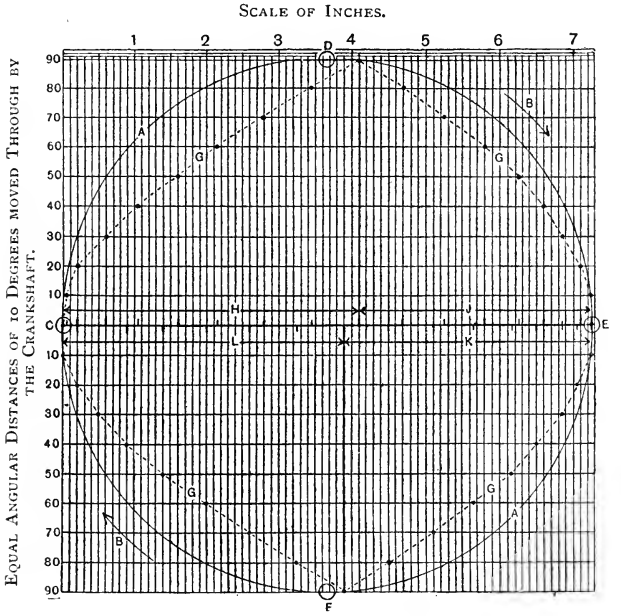
THE STROKE OF THE GOING PART.—The stroke of the going part is practically determined by the size—*i.e.*, the cross-section—of the shuttle to be used. Any attempt to form a large shed with too short a distance between the fell of the cloth and the healds, can only result in the warp threads being subject to excessive tension. The distance travelled by the going part during such time as the crank is turning from the front to the back centre is determined by the sweep of the crank, the position of the connecting pin in the lay sword, and also in a minor degree by the position of the crankshaft in relation to the oblique plane passing through the centre of the connecting pin, when in the full forward and backward positions respectively. When the centre of the crankshaft is placed in the same plane as the connecting pin referred to, the distance travelled by the connecting pin will be equal to the sweep of the crank. It is usual to fix the connecting pin in the lay sword immediately behind the point of resistance to the going part when beating-up takes place (such position being selected in order to prevent breakages of the lay swords). The stroke, therefore, of the going part will coincide with the stroke of the pin when the above conditions obtain. It is occasionally required to make a

slight alteration in the position of the bottom-shed line of the warp, and, consequently, in the relative position of the going part. The height of the going part is readily effected by an alteration in the length of the lay swords. When this is necessary the stroke of the going part will also be affected, due to the centre of the crankshaft not now being in the same plane with the connecting pin as referred to above.

There are two factors which necessitate the stroke of the going part being made as short as possible. First: When considered in relation to the speed at which it is desired to run the loom, it will be obvious that the larger the crank employed the greater will be the distance travelled by the going part, and consequently more time must be allowed. This factor evidently fixes the limit either to the stroke or to the speed at which the loom could be run. Second: It is not desirable to have too large a stroke, otherwise the chafing to which the warp is subject by the action of the reed will be increased.

THE NATURE OF THE MOTION IMPARTED TO THE GOING PART. — It must not be assumed that the following remarks profess to deal conclusively with this part of the subject. The nature of the motion obtained by means of a crank is practically the style of motion to be desired. Fig. 10 is introduced with the object of illustrating in a simple manner the variation of the movement, or the eccentricity transmitted from the crank to the going part. The particulars have been taken from a well-known type of loom, the measurements being recorded to the nearest twentieth of an inch, and are therefore only approximately correct. The circle A represents one revolution of the crankshaft turning in the direction of the arrow B. The radius of the crank is $3\frac{5}{8}$in., yielding a stroke to the

connecting pin of $7\frac{1}{4}$in. The connecting pin is 17in. from the crank, the connector arm being 17in. long. The distances travelled by the pin for each ten degrees of the crank's revolution, or in this particular instance for a movement of one tooth in the spur-driven wheel of the driving motion, fixed on the end of the crankshaft,



Distances moved by the connecting pin in 20ths of an inch.

Fig. 10.

and which contains 36 teeth, were found in the following manner:—Commencing with the crank as near as possible on the front centre C, and turning it ten degrees in the direction of the arrow B, the distance travelled by the connecting pin was recorded; then the crank was turned ten degrees and the distance recorded as before. This

order was repeated until the crank was again on the front centre.

The broken line G is obtained by plotting through the points already recorded; these points representing the distance travelled by the connecting pin for each 10° of rotation of the crankshaft, or the distances travelled in equal times. For the sake of clearness each of these points is shown projected on to the centre-scale line. From this scale the diversity of the movements imparted to the connecting pin, and simultaneously to the going part, at various stages of the crankshaft's revolution, may now be noted.

Reading from the front centre C to the first point, the distance moved by the connecting pin is shown to be $\frac{1}{20}$th of an inch; for the next 10° $\frac{3}{20}$ths of an inch. The next reading shows a much greater distance—namely, $\frac{8}{20}$ths of an inch. From this point a gradual increase is noticed for each 10° until the crank has reached the top centre D. Tracing the line G forward from the top centre it will be noticed that the distance from point to point gradually diminishes until the back centre E is reached. From the back centre to the bottom centre F the distances increase in similar (but inverse) ratio as they decrease from the top to the back centre. From the bottom centre to the front centre the distances decrease in similar inverse ratio as they increase from the front to the top centre.

Motion of the Going Part During the Time the Crank is Turning About the Four Centres.—The following comparisons may now be made, the difference in the respective distances only being calculated to the twentieth of an inch. (*a*) The total distances travelled by the connecting pin during the time the crank is turning from one centre to the next are indicated by the lines H, J, K, and L respectively, and are shown to be accord-

ing to the order of rotation 82, 63, 67, and 78 twentieths of an inch. (*b*) Comparing the distances travelled by the crank for each 90°, or from one centre to the next, with the above distances of the connecting pin, it will be observed that the pin moves a greater distance by $\frac{8}{20}$ths of an inch more than the radius of the crank during the first 90°. While the crank is turning from the top to the back centre, the distance travelled by the connecting pin when compared with that of the crank is $\frac{8}{20}$ths of an inch less. During the time the crank is turning from the back to the bottom centre, the distance of the connecting pin, compared with that of the crank, is shown to be $\frac{4}{20}$ths of an inch less; and while the crank is passing from the bottom to the front centre, the pin moves $\frac{4}{20}$ths of an inch more than the crank. (*c*) A further comparison may now be made with respect to the difference of the dwell which takes place in the going part, during the time the crank is turning an equal number of degrees about the front and back centres. Taking an equal number of degrees, say 40, on each side of these centres, the distances travelled by the going part at these periods are as follows:—The distance travelled for the 40° as the going part approaches the front centre is $\frac{18}{20}$ths of an inch; the distance for the 40° as the going part recedes from the front centre is $\frac{2}{2}\frac{1}{0}$ths of an inch. This gives a total distance of $\frac{3}{2}\frac{9}{0}$ths, practically 2in. The corresponding distances for the same number of degrees about the back centre are shown to be $\frac{1}{2}\frac{3}{0}$ths and $\frac{1}{2}\frac{5}{0}$ths, giving a total distance of $\frac{2}{2}\frac{8}{0}$ths of an inch, or 1.4in. This proves clearly that the going part travels more quickly when the crank is turning about the front centre, than when turning the back centre, as it travels a greater distance in the same time; but the lengthened pause or dwell occurs exactly at the time when most needed—*i.e.*, as the shuttle travels across the race. (*d*) The

variable movement of the going part is shown to be most in evidence during the time the crank is turning an equal number of degrees about the top or bottom centres, and compared with the movements about the front and back centres respectively. The going part moves 2in. for 40° at the front centre, but for the same number of degrees about the top centre a distance of 4.6in. Briefly stated, this variable movement is brought about by the change in the position occupied by the connector arm at various stages of the crank's revolution.

Factors which Influence the Eccentric Motion of the Going Part.—It will be understood that the above remarks have reference to the loom, and similar looms, from which the particulars have been obtained and the comparisons deduced. The eccentricity of the going part is not the same on all looms. The amount of eccentricity is determined by the size of the crank, the length of the connector arm, and the relative position of the crankshaft to the connecting pin. It is usual to build broad looms with a large crank and a short connector arm, as more eccentricity is then imparted to the going part, which allows more time for the passage of the shuttle across the race. This is brought about by reason of the dwell being protracted about the back centre, in comparison with the dwell about the front centre, as this would be reduced in corresponding proportion by the use of a large crank and a short connector arm. In such looms a suitable projection is made on the lay sword behind the going part in order to allow the required space for the healds between the going part and the healds. In narrow looms a small crank and a long connector are employed, by reason of which the dwell about the front and back centres approximates to one of equal dimensions, only a slight dwell on the back centre being necessary in such looms.

In broad looms, and also in looms of medium width, where it is not desirable to employ a large crank on account of the speed at which the loom is required to be run, eccentric wheels are introduced into the driving motion. These wheels are set in such relation to each other that the speed of the crank and the going part is reduced about the back centre for the passage of the shuttle, and accelerated about the front centre.

THE POSITION OF THE REED WHEN BEATING-UP.—On some looms the position of the going part, and consequently the position of the reed when beating-up the weft, does not allow of any alteration. This is brought about by reason of the rocking shaft C, Fig. 9, being centred in a fixed position. In some looms the journal is made in the loom frame; therefore, any adjustment in the position of the rocking shaft is impossible. On other looms the rocking shaft is supported in a movable bracket, so that a slight alteration in the position of the going part and the reed may be effected. If the methods adopted on many modern looms might be taken as evidence, the tendency is to make the position of the rocking shaft a fixed one. This decision on the part of the loom-makers is substantiated by practical experience, and especially for looms weaving a variety of cloths.

The reed at the beat-up should never be any further forward than a vertical plane passing through the centre of the rocking shaft. If the reed be allowed to pass this point, the probable result will be that instead of the reed meeting the cloth at right angles to the warp line A, Fig. 11, and thereby giving a smart blow to the weft, the cloth will slide down towards the bottom of the reed B. In addition to this, when the reed passes the vertical plane referred to, the lay F begins to dip, and as a result the maximum amount of vibration in the going part takes place, to the extent of the chase in the rocking shaft

C and connecting pin F, Fig. 9. When the position of the rocking shaft is fixed, the angle formed by the reed with the warp line can only be altered by a change in the position of the back rail C, or of the breast beam D. For general and practical purposes the position of the reed with the warp line is best as shown in Fig. 11—*i.e.*, forming a right angle.

Resistance of the Warp to the Beat-up in Different Weaves.—Obviously the best result would be obtained with the reed inclined at such an angle

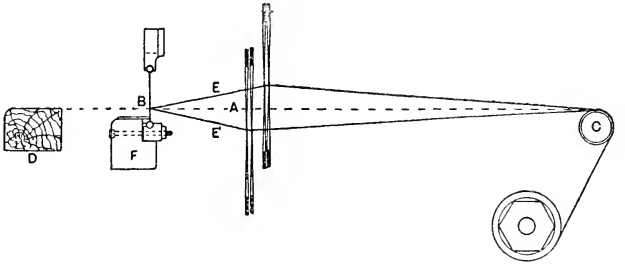


Fig. 11.

when beating-up as to act in an opposite direction to the pull or resistance of the warp. The direction of the pull is not always the same; the style of the shedding motion, also the design of the fabric, will determine and effect an alteration in the direction of the pull. Referring, for example, to an open shed loom, the resistance of the top and bottom parts of the shed E and E^1 with designs similar to A, Fig. 12, which flush the warp and weft equally on each pick, will be the same. The result will not be influenced in any degree by those threads which are changing positions, as these, being slack, do not offer any resistance; therefore, the full force of the beat-up must be sustained by those threads which are tight.

Taking another example, with the design as at B, Fig. 12, where there is a preponderance of warp flushes in the proportion of 13 to 4, and only two threads change positions on each pick, the greater pull will be with the top part of the shed in the direction of E, or, if woven face down, in the direction of E^1. Following out the above remarks, the best result for such designs would be to incline the reed at such an angle which will oppose the direction of the greater resistance. Again, when weaving weft-backed or double cloths, as shown at designs C and D respectively, the greater pull will alternate in the direction of E and E^1, according as the face or backing

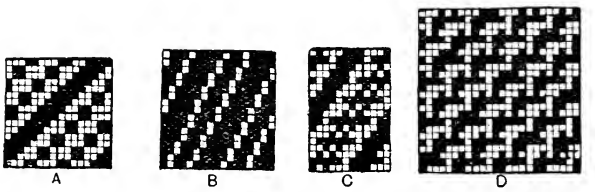


FIG. 12.

pick is being inserted. It will be observed, therefore, that the position of the reed in looms engaged in the weaving of cloths constructed from designs A, C, D, the best position for the reed at the beat-up will be the medium position as shown in Fig. 11. The foregoing remarks also apply to looms built on the centre-closed-shed principle, while looms built on the bottom-closed-shed or semi-closed-shed principle require separate consideration.

RELATION AND TIMING OF THE VARIOUS MOTIONS.—The present is an opportune moment for a consideration of the various motions of a loom as performed during one revolution of the crankshaft, and their relation to each

other. It will be advantageous if the motions are considered with reference to Fig. 10. As this diagram illustrates the variable movement of the going part, it will be seen more clearly how important is the timing of the several motions to each other, and, in addition, the timing of the motions which are more directly affected by the variable speed of the going part may be observed.

The circle of timing is shown in Fig. 13, the particulars being taken from the same loom as were those for Fig. 10, but they are more or less typical of the cycle of operations performed on most tappet and dobby looms. The only point of difference is the direction in which the crankshaft rotates, which, in this instance, is as shown by the arrow B; but it may be mentioned that this order of rotation is not generally adopted.

PICKING MOTION.—The position for the timing of the picking motion may be first located. This motion admits of little alteration with respect to the time at which it may operate. The timing shown is the medium position, and may be altered to take place from 10° to 15° sooner or later, according to requirements. The timing is indicated by the radial lines A, D, D_1, D_2, and D_3. The line A D shows the position for the commencement of the pick—*i.e.*, the picking bowl is just in contact with the shoe. D_1 denotes the position at which the picking connections are drawn tight, with the shuttle beginning to move out of the box. D_2 shows the position for the delivery of the actual blow to the shuttle. The distance from D_2 to D_3 indicates the time allowed for the passage of the shuttle across the race, though the position of D_3 varies considerably, being determined by the reed space of the loom, and the weight of and resistance to the shuttle. Taking this illustration as being typical of a 10/4 loom, then the number of degrees for the pas-

sage of the shuttle will be rather less in a narrower loom and more in a broader loom.

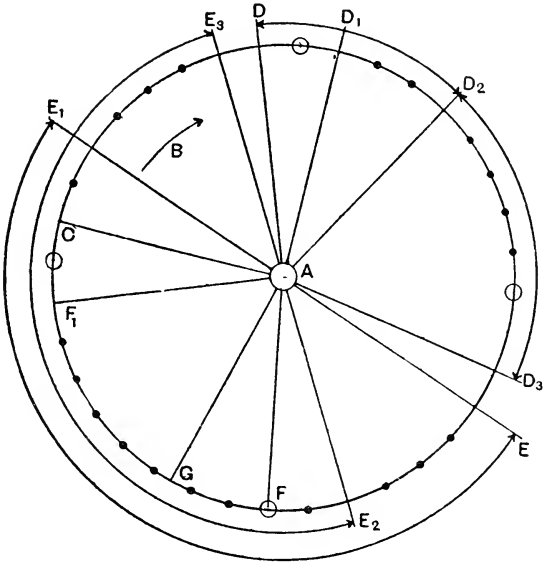


FIG. 13.

INDEX TO CIRCLE OF TIMING.

A C = Beat-up.
A D = Preparation for picking.
A D_1 = Shuttle begins to move.
A D_2 = Pick delivered.
D_2 D_3 = Passage of shuttle.
A E = Healds begin to change when in earliest position.
A E_2 = Healds begin to change when in latest position.
A E_2 = Boxes begin to change.
A F = Weft stop motion locked.
A G = Warp protector blade locked.
A F_1 = Weft stop motion stops the loom.
A E_1 = Healds finish changing when in earliest position.
A E_3 = Healds finish changing when in latest position.
A E_3 = Boxes finish changing.

SHEDDING MOTION.—In this particular type of loom, one-half of the revolution of the crank is occupied in the

formation of the shed, and the remaining half—*i.e.*, 180° —for the dwell of the healds. As the picking motion requires only one-third of a revolution, or 120°, it is evident that considerable scope is afforded for the timing of the shedding motion—to the extent of 60°. The earliest position at which shedding can take place is immediately after the shuttle has passed through the shed—*i.e.*, at point D_3. When shedding commences at point E, the shed will be completely formed 180° later, as shown at E_1, which is 20° past the point of the beat-up. The latest position at which the shed can be formed is determined by the position at which picking commences, as the shed must be fully formed to admit the shuttle at this point. Marking 180° backward from the point E_3, the latest position at which the formation of the shed can take place is shown at E_2, so that the shed would be more than half formed at the time of beating-up. In some dobby looms more time is allowed for the formation of the shed, with a corresponding less time for the dwell of the healds. In two-tappet looms the principal allowances are $\frac{1}{2}$ for the change and $\frac{1}{2}$ for the dwell, or $\frac{2}{3}$ for the change and $\frac{1}{3}$ for the dwell.

Box Motion.—The boxes must have arrived at a state of rest before the picking can take place, and they must remain in that position until the shuttle is well into the opposite box. On many looms fitted with a rising or drop box motion, the time allowed for changing the boxes is equal to $\frac{1}{2}$ a revolution of the crankshaft, which then allows $\frac{1}{2}$ a revolution for the boxes to remain stationary, yielding 60° clearance in excess of the time taken up by the picking. In looms fitted with a circular box motion the time for changing the boxes is rather less. It is usual to time the box motion so that the boxes are not less than halfway changed in position at the time of beating-up.

When in this position the shuttle-checking motion has allowed the pickers to fall back, and, being quite clear of the box shelves and shuttle tips, they cannot then obstruct the movement of the boxes. The position of timing is shown in Fig. 13, commencing at point E_2 and finishing at E_3—*i.e.*, the boxes are set level with the shedding motion when the latter is in its latest position.

The warp protector stop motion and the weft stop motion are instantaneous and not protracted in their action, as are the motions already dealt with. The positions at which these motions take place are shown at points G, F, and F_1 respectively. This remark is also applicable to the beat-up, which, in this instance, occurs at point C, which is 10° past the front centre.

Letting-off and Setting-up Motions.—When these motions are of a negative character, they are performed simultaneously with the beating-up of the weft. If they are of a positive nature, the timing will vary according to the style of the mechanism employed.

Of the several motions discussed, it will be observed that the passage of the shuttle, the box motion, and the warp protector motion, is more or less affected by the eccentricity of the going part. Referring to the amount of work done at any period of the crank's revolution, it will be noticed that the most strain is put upon the loom about the front centre, as then the shedding, box and beating-up motions are being simultaneously manipulated, whilst the loom practically runs light during the time the crank is turning the back centre.

CHAPTER III

SHEDDING MECHANISM

THE simplest type of shedding motion is that in which the shed is formed by means of tappets. This principle lends itself in various forms to extensive application. The principle of this type of shedding consists in using a tappet which impinges upon an anti-friction roller supported in a lever, known as the treadle, the heald shaft being connected, directly or indirectly, to the treadle from which it is operated. The contour or throw of the tappet may be of any form within certain limitations.

Tappet motions are constructed to give one of two systems of shedding: (*a*) Negative shedding, in which the heald shaft is operated in one direction only by the tappet—*i.e.*, the heald shaft may be lifted or drawn down, some additional mechanism being required to reverse the action of the tappet. (*b*) Positive shedding, in which the heald shaft is actuated in both directions in a positive manner. The tappets may be applied to the loom in one of two ways—either inside the loom under the healds, or outside the loom frame. Negative tappets are employed in either position, but positive tappets are placed outside the loom.

The following are typical of the variety of forms and methods of applying tappets to the power-loom for shed formation. The most elementary form of tappet shedding motion is one which is constructed to control two heald shafts; these latter receive a reciprocating motion and produce the plain weave. This is a type of inside

tappet, and is usually adopted on the ordinary calico loom. This latter is constructed to give alternate picking, the picking motion being actuated from the low shaft, which revolves at half the speed of the crankshaft. This factor enables the tappets to be fixed upon the low shaft in such a position as to actuate the treadles. The treadles are placed at right angles to the low shaft and the heald shafts; the treadles being supported at the heel from the back rail, with the end of the treadle extending forward, so as to be easily connected to the under side of the heald shaft.

This principle is also occasionally applied in combination with other forms of tappet shedding, the object being to operate the skeleton shafts employed to control the selvage threads, which work plain, the weave for the body of the material being twill or some other order of interlacing. The former principle is further extended by introducing a countershaft to carry the tappets. The tappet shaft is then placed parallel to the low shaft, from which it is driven by spur-wheel gearing. Some little variety of weave effect may be obtained by this method, as there are usually four treadles employed. This form of tappet shedding is generally employed on narrow looms engaged in weaving light goods from fine yarns. By reason of the small space available for the treadles and tappets, this method imposes limitations on the stroke of the tappets and the number of treadles that may be employed. The principle of inside tappet shedding is still further extended in broad looms engaged in weaving heavy goods, the weave of such fabrics usually being complete on not more than eight threads and picks. The tappets in this instance are carried on a countershaft placed at right angles to the low shaft, from which the countershaft is driven by bevel-wheel gearing. There are two types of tappets employed in

connection with this principle, known as the sectional tappet and the barrel tappet.

SECTIONAL TAPPET.—A sectional tappet and its method of application is shown in Fig. 14. The treadles A are supported at the heel by the bracket B, and kept in position by the grid C. The bracket and grid are bolted to the cross-rails, of which there are usually three in looms of medium and broad width, for the purpose of giving rigidity, as well as affording a ready means of supporting the pedestals carrying the crank and low shafts. The sectional tappet shown at D is the style required for 2×2 twill; four sections being necessary to complete the whole tappet. One of the four sections is made with a boss of metal into which a keyway is cut —for the purpose of fixing the tappets to the shaft. The series of tappets are first fastened together, as required by the order of weaving, by means of bolts which are passed through the holes shown, the bossed sectional tappet being on the outside. The tappets are placed over the treadles, the shaft being carried in the journals E of the rails F. Bevel-wheel gearing is employed for driving the tappets. To the end of the tappet shaft the bevel wheel G is fixed—containing a number of teeth which is a multiple of the number of teeth, or half the number of teeth, in the driving bevel H. For instance, if a four-pick pattern was required, the tappet wheel would contain 48 teeth, and the driving bevel 24 teeth. With these wheels, and the low shaft running at half the speed of the crankshaft, the tappets would make one revolution whilst the crankshaft was making four; with the result that the tappets produce a change of shed for each pick. The particulars for a three-pick pattern would be as follows: Driving bevel, 24 teeth; tappet wheel, 36 teeth (or some other similar proportions); and similarly for five and six pick patterns.

It is not customary to adopt this style of tappet for looms that may be required to produce cloths in which the weave occupies more than six picks in one repeat. A disadvantage of this style of tappet is that the tappets

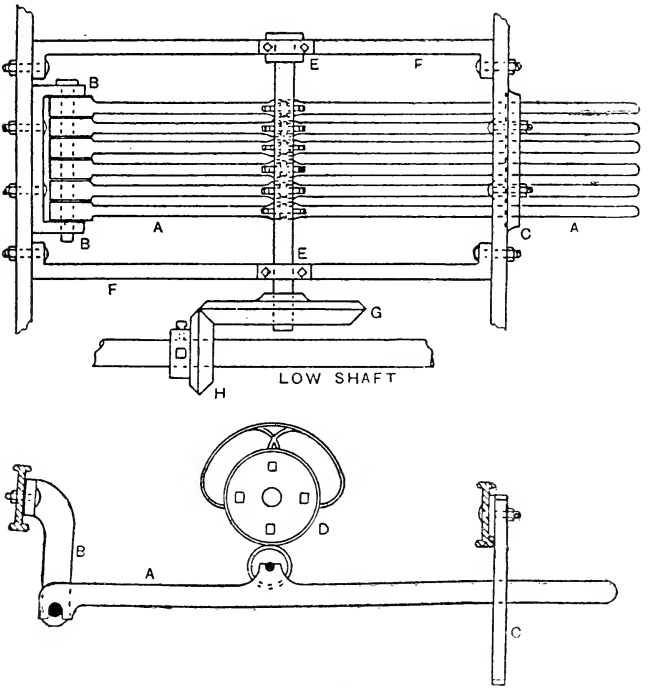


FIG. 14.

are self-contained, a separate tappet being necessary for weaves varying in the number of picks in one repeat, and also for weaves which are complete on the same number of picks, but where the order of interlacing varies. The tappets being usually left lying about the loom, breakages are also not infrequent. Some little variety in

weave effect may be produced by a rearrangement of the sections in relation to each other, or by the alternative method of crossing the cords connecting the healds to the treadles. This style of tappet is not, however, so well adapted to this latter method, by reason of the short distance intervening between the treadles and the healds —resulting in the cords chafing against the treadles and quickly wearing out.

Barrel Tappet.—This is so named on account of the barrel-shaped or cylindrical shell employed, to which segments of the required formation are bolted, the barrel corresponding to the inner circle of metal, and the segment to the throw of a sectional tappet. The construction of such a tappet is illustrated in Fig. 15. The barrel is shown in sectional elevation A, and the method of fixing the segments to the barrel at B. The segments shown at C and C^1 are for a dwell of two and three picks respectively. The make-up segment is shown at C^2, this type of segment proving useful when changing the pattern, as it may be readily bolted onto the end of other segments, in order to increase the dwell of any particular shaft, to the extent of one pick, when changing the weave. The utility of this form of tappet, when compared with the sectional tappet, is due to the increase in the number of weaves which may be readily obtained from a given number of segments; also the facility with which they can be produced.

Taking for example a barrel tappet constructed to operate eight treadles, with eight picks to the round, weaves which are complete on two, three, four, six and eight picks may be woven. To allow of the different segments being bolted to the barrel, it is provided with two sets of standard bolt holes—*i.e.*, the periphery of the barrel would contain two sets or rows of holes equal distances apart. One set is indicated at B, Fig. 15, by

the numerals 1, 2, etc. (which are $\frac{1}{8}$th of the circumference apart), to accommodate the segments for the two, four, and eight pick patterns. The other set of bolt holes is denoted by the figures 1, 2^1, 3^1, etc., which are $\frac{1}{6}$th of the circumference apart, to accommodate the segments for the three and six pick patterns.

For driving the barrel at the required speed, two change wheels would be necessary, one wheel being em-

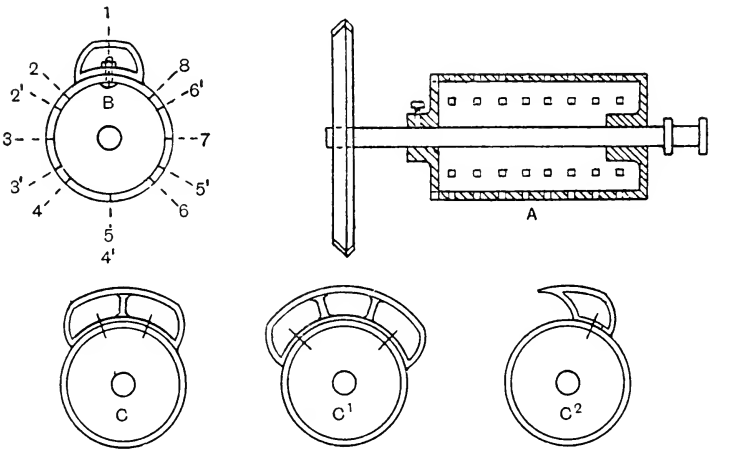


FIG. 15.

ployed for the two, four, and eight pick patterns, the two-pick pattern being repeated four times, and the four-pick patterns repeated twice, in one revolution of the barrel; the eight-pick patterns occupying one complete repeat of the barrel. The other wheel is used for the three and six pick patterns, the three-pick patterns being repeated twice, and the six-pick pattern once in a complete revolution of the barrel. The following particulars of the driving bevel wheels and the tappet

wheel would be adopted: Tappet wheel, 72 teeth; driving bevel for the two, four, and eight pick patterns, 18 teeth; driving bevel for the three and six pick patterns, 24 teeth.

As evidence of the limitations of this style of tappet,

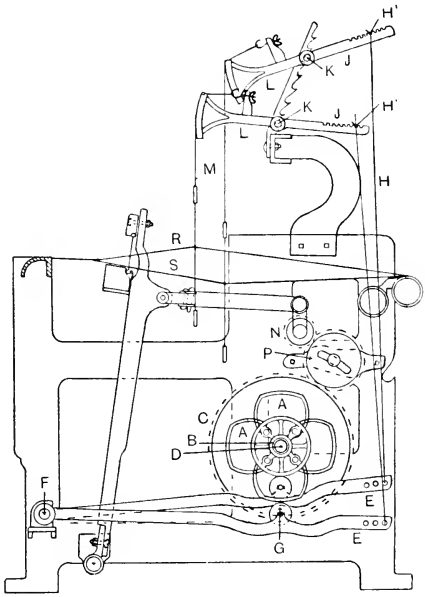


FIG. 16.

let it be assumed that a weave occupying five picks in the repeat is required. There are two factors to be considered. First, the barrel must be provided with a series of bolt holes $\frac{1}{5}$th of the circumference apart, which, in addition to those already necessary for the six and eight pick segments, would make the arrangement of the holes very complex. In addition, the selection of the par-

ticular series of holes required for the various segments would be a very difficult matter when changing from one weave to another. Second, the speed at which the barrel must rotate would require to be different from either of the two former speeds. This would necessitate a tappet wheel containing a number of teeth which is a multiple of five. Similar provision would have to be made for producing a seven-pick pattern, which, for the reasons already referred to in connection with the five-pick pattern, would make it a very difficult matter, if not altogether impracticable, to produce all these weaves on the same barrel. It would be much more feasible, if five and seven pick patterns were required, to have another barrel tappet to work 10 treadles with 10 picks to the round. This would accommodate the five and ten pick patterns, and have a second set of bolt holes made to accommodate the seven-pick pattern segments, the tappet wheel containing 70 teeth, the driving bevels containing 14 teeth for the five and ten pick patterns, and 20 teeth for the seven-pick patterns respectively, or wheels in similar proportions.

Bradford Tappet.—A very common type of shedding mechanism in which sectional tappets are employed is illustrated in Fig. 16. This is generally referred to as the " Bradford tappet," by reason of it being extensively adopted in that district. The mechanism is placed outside the loom frame as shown, and not inside the loom under the healds as in the former types. The tappets A are fixed on to the sleeve or tube B, the latter being cast in one piece with the tappet wheel C. The sleeve is placed over the end of the low shaft D, which serves as a stud, on which the sleeve and tappets may revolve. The treadles E are placed at right angles to the low shaft; the heels of the treadles are pivoted at F, and extend forward underneath the tappets. The treadles are pro-

vided with an anti-friction bowl G, on which the tappet impinges. Connection is made indirectly to the heald shaft by means of the connector rod H, which connects the end of the treadle to the lever J. This lever in turn is attached to a square shaft K. These square shafts are carried in brackets (forming a gantry), supported by the top rail of the loom, and extend to such a length as to allow of two half-moon levers L being placed one at each side of the heald shaft, to which they are then connected by the straps M.

The method of working will be understood if some consideration be given to the throw of the tappet and its relation to the stroke of the heald shaft and the size of the shed obtained. The construction of this type of shedding motion lends itself readily to the formation of a perfect shed. The throw of the tappet can be regulated to yield the exact amount of movement to the heald shaft. By careful adjustment of the winged nuts H^1 on the screw thread of the rods H, the correct position of the heald shaft in relation to the warp line is easily obtained. The lever J is also provided with a series of notches about $\frac{5}{8}$in. apart. Any alteration of the winged nut from one notch to another would yield an increased or decreased stroke of the heald shaft as the length of the lever J to the half-moon lever is increased or diminished; by this means the correct depth of the shed is readily acquired. Let it be assumed that the throw of the tappet is 3in., the throw being the distance from the inner circle to the outer circle of the tappet—*i.e.*, the treadle pulley has a stroke of 3in.; with other dimensions as follows: Distance from the treadle heel to the centre of the friction pulley, 24in.; and from friction pulley to the end of the treadle, 12in.; therefore the stroke at the end of the treadle will be as $24 : 36 :: 3 : x$, or x equals $4\frac{1}{2}$in. The winged nut is in the second notch

from the end of lever J, or a distance of 9in. from the centre of the square shaft K. The half-moon lever is 8in. long; therefore the stroke of the first heald shaft would be as $9 : 8 : : 4\frac{1}{2} : x$, or x equals 4in. If the first shaft is 12in. from the fell of the cloth, the depth of the shed 6in. from the fell of the cloth will be as $12 : 6 : : 4 : x$, or the shed will be 2in. deep. Assuming that the shuttle enters the shed at this point, this would allow of a shuttle $1\frac{3}{4}$in. deep being used, and still allow $\frac{1}{4}$in. for clearance between the shuttle and the top shed line of the warp. To obtain a perfect shed line of the warp both at the top and bottom, R and S, the winged nuts on the rods H would require to be placed nearer the centre of the square shafts for the back heald shafts—usually one notch for every two heald shafts.

Driving the Tappets and Change Wheel Calculation.—The tappets are driven from the crankshaft by spur-wheel gearing. It is customary for the tappet wheel to contain a number of teeth which is a multiple of the weaves to be produced. In this instance the tappet wheel contains 120 teeth, this number being divisible by all numbers up to and including 10, with the exception of 7 and 9. The number of teeth required in the change wheel N for weaves which are complete on 2, 3, 4, 5, and 6 picks to the round, is obtained by dividing the particular number into the number of teeth contained in the tappet wheel. For the tappets complete on 7, 8, 9, and 10 picks to the round, two intermediate wheels are substituted in place of the carrier wheel P, as neither 7 nor 9 will divide into 120 without remainder, and the factors 8 and 10 would give a wheel too small for practical purposes. Adopting a wheel on the crankshaft containing 24 teeth, then the intermediate wheels required would be in inverse proportion as 24 multiplied by the number of picks in one round of the tappets to be used

is to the number of teeth in the tappet wheel 120. For a 7-pick pattern $\left(\frac{24\times7}{120}=\frac{168}{120}\right)$ wheels in proportion of 168 to 120 would be required, but such wheels would be too large for practical working, by reason of the small space available between the wheel N and the tappet wheel C; therefore wheels containing 42 and 30 teeth respectively would be employed. The 42-wheel would be geared with the wheel on the crankshaft, and the 30-wheel with the tappet wheel C.

For the 8-pick patterns $\frac{24\times8}{120}=\frac{192}{120}$, or $\frac{48}{30}$ = driven wheel
„ 9 „ $\frac{24\times9}{120}=\frac{216}{120}$, or $\frac{54}{30}$ „ „
„ 10 „ $\frac{24\times10}{120}=\frac{240}{120}$, or $\frac{60}{30}$ „ „ driver wheel.

Looms fitted with this style of tappet are specially adapted for weaving light and medium fabrics in cotton, worsted and woollen cloths, in which the weave does not occupy more than 10 ends and picks. A few such looms are occasionally fitted to take up to 13 shafts.

Variety of Weave Effect.—With sectional tappets such as are used in the Bradford tappet loom, a variety of weaves can be readily produced by using the same set of tappets. Taking, for example, a set complete on ten picks to the round, and made to operate the heald shafts in the following order: $\frac{3}{1}\,\frac{1}{3}\,\frac{1}{1}$, as shown at A, Fig. 17, the weaves shown at B, C, D, in addition to others, may be produced. These sectional tappets are specially constructed to facilitate the production of a variety of weaves. Each tappet is provided, on the rim of the inner circle of metal, with a number of recesses equidistant apart, and equal to the number of picks on which the tappet is complete. On the other side there is a pro-

jection of metal which fits into one or other of the recesses of the adjacent tappet, each being secured to the sleeve by a set-screw when finally placed in position.

To build up a weave the tappets are set in the same relation to each other as the threads in the point-paper plan. This is best accomplished by following out the move number of the weave, which is indicated by the solid black squares in the plans given. The straight twill A has a move number of 1; therefore, having first determined the direction in which the sleeve rotates, and fixing the first tappet over the first treadle, each will be set to operate one recess later—*i.e.*, $\frac{1}{10}$th. To pro-

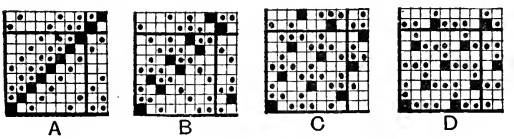


FIG. 17.

duce the weave given at B, the second thread has a move number of 3 from the first, so that the second tappet must be fixed three recesses later in relation to the first. The third thread moves one backward from the second —*i.e.*, it has a move number of—1, and must be set to operate one pick earlier than the second tappet, which in effect will be two picks later than the first, this order being repeated until the whole set of tappets is in position.

TAPPET CONSTRUCTION.—There are two important factors in connection with the construction of a tappet which require careful consideration—viz. (1) The time to be allowed during one revolution of the crankshaft for the change and dwell of the healds; and (2) the nature of the movement to be imparted to the healds, and simultaneously to the warp threads, during the

formation of the next shed. With reference to the former, in looms which are employed to weave a variety of cloths it is essential that allowance be made so that the relation of the timing of the shedding to the beating-up of the weft may be varied. There are three main reasons for this procedure:

(*a*) To Facilitate Heavy Wefting.—When weaving cloths in which it is desired to insert the maximum number of picks per inch of any given count of yarn, it is more easily effected by beating up the weft in a crossed shed, than with the shed partly crossed. It will be obvious that if the weft is pushed into position with the next shed nearly or fully formed, it will be prevented from springing back from the preceding pick, by reason of the warp threads closing over it and locking it in position. Another advantage is that a given number of picks can be put into a cloth with less weight on the warp beam, and consequently with less strain on the warp. A defect sometimes attendant upon early shedding, and resulting in excessive chafing and breakages of the warp, is due to the weft being forced into position through the crossed shed. This defect is chiefly encountered when weaving single woollen yarn, warps slackly twisted, and warps inadequately sized or unsized.

(*b*) Clearing the Shed.—Early shedding is occasionally practised in order to assist in clearing the shed when weaving cloths in which the warp is made from coarse cross-bred worsted or low cheviot woollen yarn. Such warps have a quantity of loose and projecting fibre, the natural tendency being for these to interlock with each other, or to roll up into bead form, and as a result prevent the formation of a clear shed. It will probably be remarked that sizing the warp is a sufficient remedy for this defect. But let it be assumed that an attempt

is made to weave this class of warp without sizing. Such warps are usually strong enough to resist the strain to which they are subject during weaving. To size them solely for laying the loose and projecting fibres, appears to be a somewhat unnecessary and expensive operation. The cost of production is also increased on account of the outlay in sizing plant, material, and labour involved in the process. In order to separate any adhering fibres, the shed should be timed as early as possible; with the opening of the shed the threads are subject to a degree of tension, and as further strain is suddenly applied at the beat-up, it helps to clear the shed for the passage of the shuttle. Other methods occasionally adopted with advantage are as follows: Weaving with the warp as tight as possible; bringing the lease rods nearer the back of the healds; fixing clasp laths on the warp midway between the healds and the back rest; weaving with the warp running through two reeds; and tying a thrum roller behind the slay to roll upon the top shed line of warp to collect up the loose fibres. In tappet looms the tappets may be constructed to give a long dwell and a short time for the change, with a uniform movement imparted to the heald. Any of the above methods may also be applied with advantage when weaving cords, corkscrews, and satins, the shed with these being difficult to clear, resulting in numerous weft staples in the piece.

(*c*) EARLY SHEDDING, in combination with the principle of troughing the shed, is employed for the prevention of reed marks and obtaining cover. This principle is further considered on page 98.

The allowance for the timing of the shed is determined by the construction of the tappet. The first factor to decide is the minimum dwell that can be given to the healds. This dwell in some instances is calculated to a

degree of accuracy which eventually proves to be detrimental to the working of the loom. If the time taken for the passage of the shuttle is equal to a fourth of the crank's revolution, a pause of not less than this time must be allowed for the dwell of the heald. This would leave the maximum time for the change, with the advantage of slower motion and less strain on the warp. It is evident that under such conditions the beat-up will always take place with the healds in the same position—*i.e.*, the shed at the same point of formation. Any deviation from this condition is only possible by effecting an alteration in the proportion of time to be allowed for the change and dwell. This extreme is rarely carried beyond allowing half a revolution of the crank for the change and dwell respectively. The healds may then be set in any position between the extremes as shown in Fig. 10.

Method of Drawing the Outline of a Tappet.—The method of construction is further illustrated in Fig. 18. To draw the outline of the tappet required for the interlacing given in Fig. 17, the following additional particulars are required: Diameter of treadle pulley, 3in.; diameter of inner circle, 6in.; throw of the tappet, 3in. Proceed as follows: With the radius of the inner circle describe the circle A; to this radius add the throw of the tappet and describe the outer circle B. The completed outline of the tappet will run on or between these two circles. To obtain the contour of the centre of the treadle pulley, which will be 1½in. from the outline of the tappet, describe the two construction circles C and D. These are obtained by adding the radius of the pulley, 1½in., to the radius of the two circles A, B already described. Next divide the four circles by radial lines into as many sections as there are picks in the weave for which the tappet is required—in this instance ten, de-

noted by the letters E to O. Each of these sections represents one pick of the weave and one complete revolution of the crankshaft. The sections in which the heald changes position are next subdivided accord-

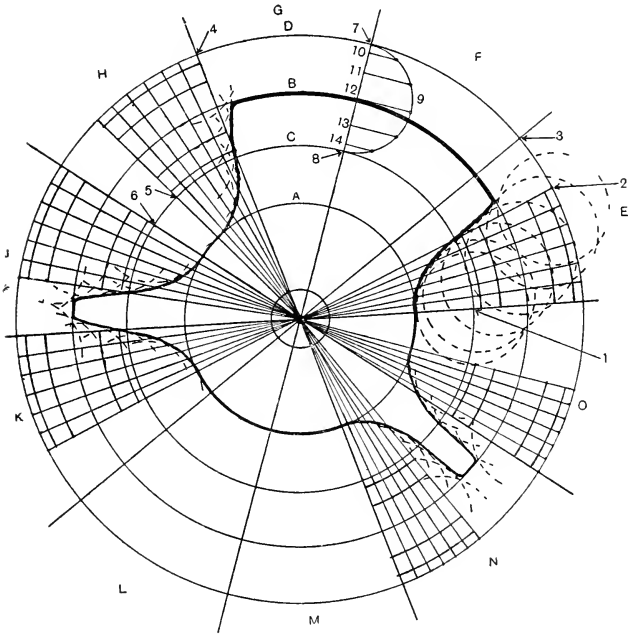


FIG. 18.

ing to the time to be allowed for the change and dwell. Commencing with section E to represent the first pick, in which the heald is indicated to be lifted, divide this section into three equal parts if $\frac{2}{3}$ for the change and $\frac{1}{3}$ for the dwell is to be allowed, or into two equal parts as shown at N and O if $\frac{1}{2}$ for change and dwell is to be

allowed. It will, of course, be understood that the time allowed for the change and dwell must be the same in each section, in the actual construction of a tappet. The line followed by the centre of the pulley will pass from point 1 to 2, and continue for the dwell on the circle D up to point 3. As the heald is required to be lifted for three picks in succession, the line is continued through sections F and G up to point 4. The heald now changes position, the line being continued through the $\frac{2}{3}$rds division of section H down to point 5 and continued on the circle C up to point 6. The heald then again changes, the line passing from the circle C to the circle D as before, but this time for one section only. It then passes to the circle C, on which it is continued for three successive sections K, L, and M. It next passes to the circle D for one section only, then back to circle C for the remaining section O, and subsequently up to the starting point 1.

Nature of the Motion Desirable for the Healds. —If it is desired to impart a uniform motion to the healds when changing position, this can be obtained by joining the points 1 and 2 where the several changes take place, by means of a straight line. But an eccentric, and not a uniform, motion is necessary, so that the healds may commence changing slowly, increasing in speed towards the middle of their traverse, and then diminishing in inverse ratio to the finish. The outline to be followed by the centre of the pulley during the change, in order to transmit an eccentric motion to the heald, is obtained as follows: Divide that portion of the several sections allowed for the change by means of radial lines, into a number of equal parts—*e.g.*, six. Next divide the space between the construction circles C, D into the same number of parts, but unequal. This may be done by dividing the line 7, 8 in arithmetical progression, or by

describing the semicircle 9 and setting off six equal distances; from these points drop perpendiculars cutting the line 7, 8 at points 10 to 14. Then with the distance from the centre to each of these points as radius, describe arcs cutting the radial lines into six unequal portions. The points where the arcs and radial lines cut each other are the points through which an outline must be drawn. This will represent the contour or path to be taken by the centre of the treadle pulley; therefore the treadle, and simultaneously the heald shaft, will move through unequal distances in equal units of time, commencing slowly, increasing to the middle of the stroke, then diminishing to the finish. The correct form of the tappet can now be obtained by setting off from the outline already formed, distances equal to the radius of the treadle pulley, by preference from the points where the arcs and radial lines intersect, as shown by the dotted circles. The final outline of the tappet is sketched in touching each of these circles where the several changes take place, and is continued on the circle A or B, according as the heald is lifted or lowered, as shown by the thick heavy line.

Reversing Motions for Tappet Mechanism.—The tappets previously considered are without exception of a negative character. The tappet actuates the heald shaft in one direction only. Inside tappets draw down the shaft, whilst outside tappets lift the shaft. In order to draw back the shaft into its original position—*i.e.*, to convert the negative action into a positive one—various methods are employed.

Weights.—Formerly, in outside tappet looms flat iron weights about 9in. long, 5in. wide, and $\frac{3}{8}$in. thick, were suspended from the bottom of the heald shaft, one at each side. Weights are defective, as they do not afford any medium of regulating the pull on the shaft, such as

may occur for heavier-tensioned warps. The addition of an extra weight would probably be in excess of the requirements, and result in unnecessary driving power being expended. Weights are also defective, as they apply a uniform pull irrespective of the position of the heald shaft. The ideal reversing mechanism should ease the tension as the healds gradually approach the end of their traverse.

Springs.—These are more frequently employed to reverse the action of the tappet, and are readily adapted to any style of negative tappet. When springs are applied directly to the heald shaft, they are very unsatisfactory, as they exert a greater strain upon the heald and the loom the further the spring is extended. This tension, increasing with the stroke of the heald shaft, taxes the loom to its utmost capacity, and acts in an entirely opposite manner to the condition required for an ideal motion. A further defect experienced with both weights and springs is the irregular running of the loom, especially when weaving designs with uneven sheds. To the defects already enumerated should be added the expense incurred in healds and cord, as these inevitably wear out much more quickly than under more favourable treatment.

Heald Pulleys.—When conditions are favourable to their adoption, heald pulleys form the ideal motion. In their simplest form they consist of a stepped or eccentric pulley. Fig. 19 shows the construction of a single heald pulley as used for controlling two heald shafts. The pulley A is supported in a bracket B which can be readily fixed to some convenient position on the loom, usually to the loom rails, either under or over the healds. The eccentric side C is requisite in order to allow a greater stroke to the heald shaft farthest away from the fell of the cloth. The strap is passed round the

pulley and fixed by means of the set-screw D. These pulleys are only applicable to weaves in which the healds can be coupled together, on account of the interlacing

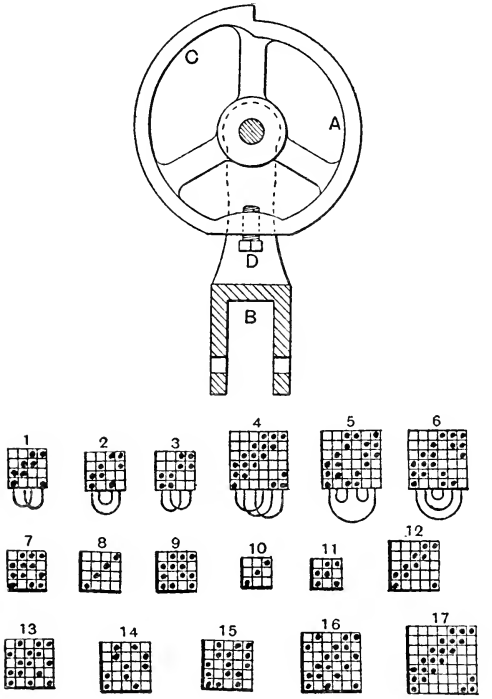


FIG. 19.

of two threads, not necessarily adjacent, in the weave being the reciprocal of each other. Taking, for example, the weave given at 1 (2-and-2 twill): the first thread works 2 up and 2 down; the reverse of this movement is found in the third thread, which works 2 down and 2 up. Consequently, the two heald shafts on

which these threads are drawn may be connected together through the medium of a heald pulley. As the first heald is actuated by the tappet, the third thread will be drawn in the opposite direction, and *vice versa*. Similarly with the second and the fourth threads and shafts. Other weaves for which heald pulleys may be applied are given at 2 to 6, Fig. 19, in addition to others, the reverse threads in the weaves being connected as shown. The limitations of this simple contrivance will be at once evident, as it is not applicable to weaves complete on an odd number of threads, and is rarely used for weaves occupying more than six threads and picks. A modification of this principle was applied to the old type of upright or top swing looms. Levers were substituted for the heald pulleys, such an arrangement being usually referred to as the " skittles."

STOCKS AND BOWLS.—These consist of a combination of heald pulleys of various sizes mounted on stocks or shafts; or of heald pulleys compounded with a lever. They are of greater utility than ordinary heald pulleys, and may be employed for those weaves in which the movements of the threads, not being reversals, do not admit of the heald shafts being coupled together. They are limited to those weaves which have the same number of shafts lifted and depressed on each pick. As examples, the weaves given at 7, 8, and 9, Fig. 19, are taken, which are complete on four ends and picks, but do not admit of the application of heald pulleys, as no two threads are reversals. Other similar weaves are given at 10 to 17 on 3, 5, 6, and 7 shafts respectively, for which this reversing motion is eminently adapted.

Two types of this mechanism are shown. Fig. 20 shows in end elevation the arrangement with heald pulleys mounted on a stock to work seven heald shafts. The method of supporting the pulleys is shown at C.

These are compounded together in such a manner that upon any slackening of one or more heald cords there must be a corresponding take-up on some of the other

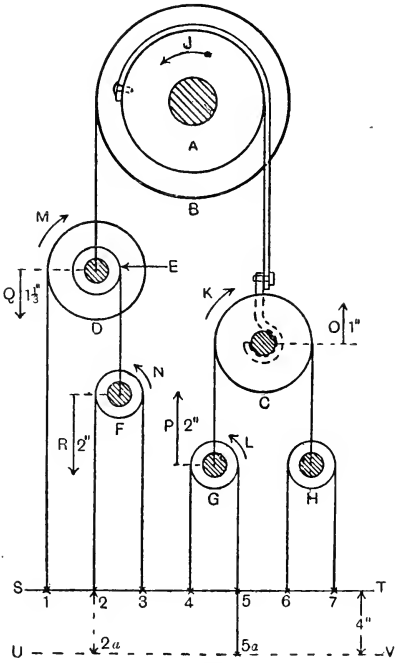


FIG. 20.

cords. Fig. 20 shows the fifth heald shaft down; and assuming that the stroke of the healds is 4in., and that for the next move this shaft is indicated to lift and the second shaft to be drawn down, we will trace the several movements which must necessarily take place to effect this change in position. The bowl C will lift one inch in the direction of the arrow O, this being accomplished by

A B turning in the direction indicated by the arrow J. The result of such a movement would be to lift the bowls H and G one inch each; but the bowl H is held in position by the tight heald cords 6 and 7. Therefore the giving-out movements can only be effected through the bowl G, which is lifted one inch by the rising of bowl C, and another inch by reason of this bowl being turned in the direction of the arrow K. As the bowl G is raised 2in. in the direction of the arrow P, the heald cords 4 and 5 should each give out 2in.; but the heald cord 4 is tight, and by reason of this will turn the bowl G in the direction of the arrow L to take up the remaining 2in. of the slack cord 5—5*a*. Next trace out the compensating movement which takes place in the bowls D and F in order to allow the heald shaft No. 2 to be lowered.

The diameters of the stepped pulleys A and B are in the proportion of 3 to 4, so that the bowl D will be lowered 1⅓in. as at Q. This causes a slackening of the heald cords 1, 2, and 3 to the extent of 1⅓in. each, but the shaft 2 only can move, and that 4in. As the heald cord 2 is drawn in the direction of 2*a* it will take up 1⅓in., and also draw the bowl F round in the direction of the arrow N to take up the 1⅓in. of the heald cord 3. At the same time, it will draw round the stepped bowl D E by pulling at the small step E to the extent of ⅔in. This allows the bowl F to be lowered, yielding ⅔in. of slack cord to each of the healds 2 and 3; but this slack is taken up by the heald shaft 2, which is only drawn down. The compensating movement between the two stepped bowls E and D, the proportions of which are as 1 to 2, results in their turning in the direction of the arrow M and taking up the 1⅓in. given out to the first heald attendant upon the lowering of the bowl D. When stocks and bowls are employed for weaves which occupy an odd number of shafts, it is of the utmost importance

that the diameters of the stepped pulleys should be in correct proportion to each other, otherwise there will be undue strain placed upon the heald cords, in addition to a defective shed being formed. The greater leverage is always relegated to the side from which the smaller number of shafts are suspended, as shown in Fig. 20, the proportions being determined by the number of shafts on which the weave is complete.

Fig. 21 illustrates an alternative method of compounding the bowls with a lever. The lever A is supported in the bracket B, which is fixed to the loom rail by means of the hand-screw C. The bowl D is carried in the block E pivoted to the lever A. Provision is made for attaching other pulley blocks at F, G, H. This method possesses an advantage over the stepped bowls fixed to a stock, for the following reason. The proportions of leverage are more readily obtained when required for weaves occupying an odd number of shafts. The respective distances are shown along the line J K, the connections being more easily adjusted according to requirements. Two sets of bowls, as shown in Fig. 20, used in combination with the lever illustrated in Fig. 21, could be so arranged as to serve for all weaves, complete on any number of threads up to eight, provided that the same number of shafts are lifted and depressed on each pick.

It will be observed that of the several types of reversing motions already dealt with no single motion is applicable to every order of interlacing or variety of weave. Some restriction is imposed with each type that prevents its general adoption.

KENYON'S AND SIMILAR UNDER-MOTIONS.—Whilst one or other of the former methods employed for reversing the heald could be utilised for the majority of weaves produced on the negative tappet loom, some pro-

vision must be made for the exceptions. There is one general type of such motion which, although constructed in a variety of ways by the several makers, all embody the same principle. In such motions the heald shafts are quite independent of each other, and on that account can be employed for any weave, irrespective of the order of interlacing or the number of shafts to be lifted and

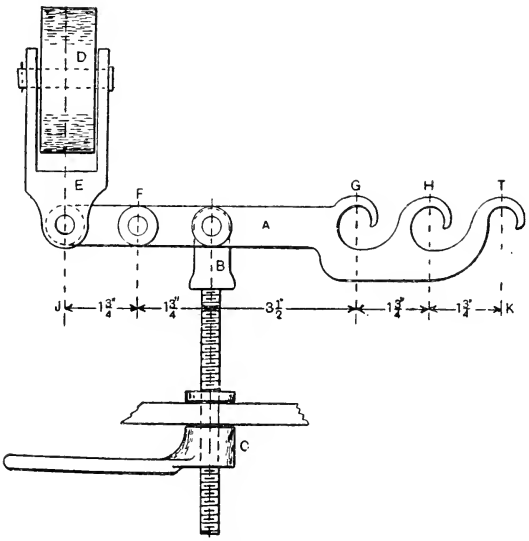


FIG. 21.

depressed for each pick. The construction of two such motions is shown in Figs. 22 and 23. The spring A is employed for reversing the action of the tappet on the heald shaft. The feature of these motions is the method of applying the spring through the medium of tumblers or levers to the heald shaft. In Fig. 22 is illustrated Kenyon's under-motion, which is extensively adopted on both negative tappet and dobby looms. The spring

is not applied directly to the heald shaft, but is used in combination with the specially constructed tumblers B. These tumblers are fulcrumed on the stud C, the stud D serving as a check pin to the tumbler when the latter is drawn back. The studs are suitably carried in the chairs E, which may be pushed further apart or drawn closer together by means of the expansion bolts F for the purpose of increasing or decreasing the power of the spring on the heald shaft. The tumblers are also

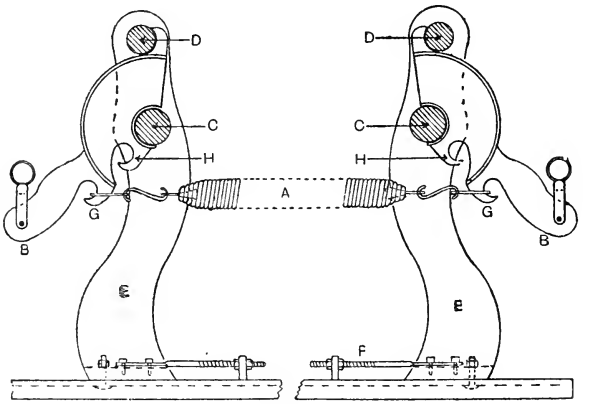


FIG. 22.

provided with two hooks G and H, on to either of which the spring may be attached, or, as is occasionally required for heavy goods, two springs may be attached to the same tumbler. This type of motion when applied to tappet looms is constructed with one layer of springs to work up to ten shafts; when employed for single-action dobbies it can be obtained with two sets of tumblers and two layers of springs. The chief feature of this and similar motions is the mechanical advantage derived from the method of applying the spring. The spring

exerts the greatest pull on the heald shaft when down, by reason of having the greatest leverage from the fulcrum stud C. As the shaft is lifted the leverage diminishes, in proportion as the connecting link approaches the stud C, and this alters the direction of the force. The pull on the heald shaft is just sufficient to draw it back into position when released by the treadle. This motion relieves the loom of the heaviest part of its work, and places less strain on the loom when weaving with uneven sheds. The motion can be applied to any pattern without any alteration of the undergear, and also prevents the healds from being overstrung, which reduces the cost

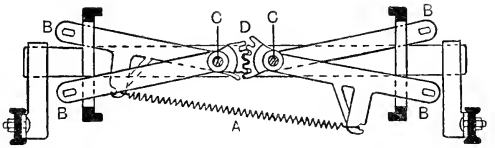


FIG. 23.

of both healds and cords. More power is consumed with such under-motions when compared with heald pulleys or stocks and bowls. Fig. 23 is similar to the above, the points of difference being that one spring A is employed for two heald shafts, the levers B being fulcrumed on studs C and geared with each other as shown at D.

POSITIVE TAPPET MECHANISM.—A positive shedding tappet, and the one most generally employed, is known as the Woodcroft tappet. This style of tappet is self-contained, and is now made in three different forms, according to the class of fabric for which it is to be adopted. Fig. 24 shows in sectional side elevation the construction of one form of this tappet. The treadles A are fulcrumed on the shaft A^1, and are provided at A^2 with a knuckle, on which the antifriction pulley is

pivoted. The pulleys are specially tempered or made of steel in order to better resist the friction to which they are subjected. The movement of this pulley, and at the same time the treadle A, is determined by the shape and the arrangement of the section plates 1 to 12. In this type of tappet only two different section plates are used. That shown at B is employed to raise the treadle; that shown at C to depress the treadle. The pulley is actuated by the projecting rims of metal cast on the side of the plates with which it is in constant contact. The healds are connected to jack levers placed above and below the healds; the levers extend outside the loom frame, and in turn are attached to the end of the treadle by means of the connector D. When the treadle is forced upwards by means of a section plate B, the heald shaft is drawn down, and *vice versa*, with the section plate C. These tappets are made to work with from 8 to 12 treadles, and can be constructed for weaves containing up to 24 picks to the round. Fig. 24 illustrates a tappet containing 12 sections or picks in one repeat. The tappet shaft E is supported in open bearings in the framework, and secured to this shaft is the tappet wheel F, containing a number of teeth (in this 180) which is a multiple of the weaves for which the tappet may be required. The wheel is also fitted with a number of standard bolt holes, in order to accommodate section plates of different sizes, such as are required for weaves containing a varying number of picks to the round.

The method of building up a tappet—*i.e.*, placing the sections in position, as required by the order of interlacing—is determined: (*a*) According to the relative position of the tappet to the loom. Usually the tappets are placed at the opposite end to the driving motion of the loom, consequently there are right and left hand tappets. (*b*) The direction in which the tappet revolves

must also be considered before commencing to place the section plates in position. The tappet is driven direct from the crankshaft by means of a spur wheel, or by a spur and pinion wheel, to facilitate changing the speed of the tappet as occasion may arise, when changing to a weave containing a different number of picks to the round—*e.g.*, from a 12 to a 9 pick pattern. When the above factors are carefully considered little difficulty is experienced in building up a tappet to produce any given weave. The real difficulty is encountered when after the completion of, say, a 12 × 12 pick pattern a mistake is discovered in the working of one or other of the treadles. This necessitates pulling down the tappet as far as the defect to again rebuild.

To build up a tappet for the order of interlacing as given at G, a convenient number of bolts are first passed through the tappet wheel, and not one bolt for each section plate. The first order of working to be built up is for the last thread in the design, on account of the treadle nearest the tappet wheel actuating the back heald shaft. The first section plate as indicated by a mark on the first pick of the last thread is a lifter C. The tappet revolving in the direction of the arrow, the next section plate will be placed to the left of this, and which from the reading of the second pick on the last thread must be a sinker B. The section plates being slightly dovetailed at their edges help to keep each other in position until the full complement of plates for operating the first treadle have been fixed as shown from Nos. 1 to 12 on the tappet. A ring plate, shown shaded with projecting rims of metal fitting into the corresponding recesses on the section plates, is then placed to keep the sections in position. The above order is repeated for the working of the next treadle, which controls the working of the last thread but one in the design. This

process is repeated until the tappet is complete, when the bolts are screwed up to keep the section plates firm and rigid.

The utility of this form of tappet is due to the scope afforded for producing variety of weave effect from the same set of section plates. Taking, for example, a

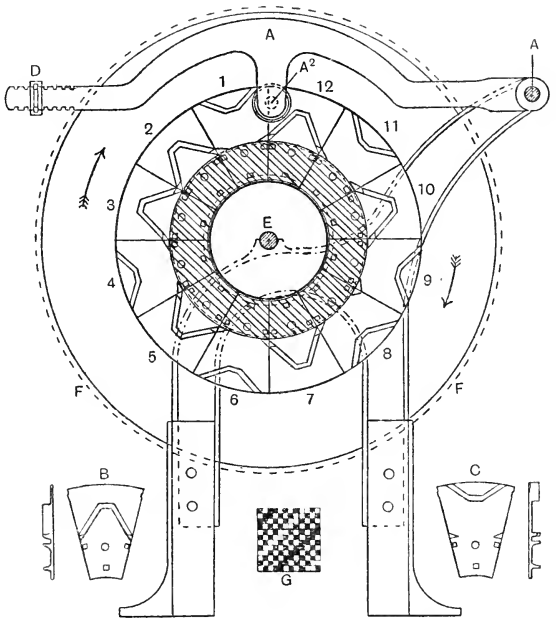


FIG. 24.

tappet constructed with 12 treadles and 12 picks to the round, and a full set of section plates—then any weave complete on 12 ends and picks, also weaves complete on 2, 3, 4, 6 ends and picks, could be produced. For the above reason this tappet is specially suitable to those branches of the weaving industry where some scope for

weave effect is desirable. It has been largely used in connection with cotton weaving, but is now being superseded by the dobby. The style of shed produced is known as "centre closed"—that is, the healds are all brought back to the centre line after the insertion of each pick. This factor makes this type of tappet useful for the production of the simple styles of leno and gauze effects. Another form of this tappet is obtained by making the section plate in one solid piece, and not built up of separate sections. This form of tappet is often referred to as the box tappet, and is no doubt much better than the former, if it is required to be kept on one particular weave. When made in this form there is no possibility of the sections working loose; therefore it is eminently suitable for heavy work, notably the heavy builds of woollen and cotton cords, corduroys, fustians, etc.

A third form of this tappet is that now made to produce open shedding—that is, the healds remain lifted or depressed for the requisite number of picks; only those threads move which have to change their position for the next pick. If, for example, the weave is a simple twill, complete on six ends and picks, each thread working $\frac{3}{3}$, the healds when once lifted or depressed would remain in that position for three successive picks. This form of tappet is well adapted for weaving light and medium fabrics. To produce open shedding, duplicates of eight different section plates are necessary, as compared with duplicates of two section plates in the former tappet. The main advantage of each of these forms of tappet is attributed to the fact that when once the pattern is correctly built up, that pattern will be produced without any danger of lost, broken, or short pegs, and other causes incidental to heald missings in dobby looms.

CHAPTER IV

DOBBY MECHANISM

With the object of obtaining increased figuring capacity in pattern production, beyond what is possible by the use of tappets, dobbies are employed. In this respect the dobby loom occupies a medium position between the tappet and the jacquard loom. There are several well-known types of dobby mechanism in general use, ranging in their capacity from 16 up to 48 heald shafts, which are practically unlimited in the number of picks a pattern may occupy. The capacity of the dobby varies with the type of loom according to the class of fabric for which it is to be utilised. The style of cloths chiefly produced in some districts is such as to require a dobby ranging from 16 up to 24 shafts. Again, taking the fancy worsted and woollen trade of Huddersfield, and districts where similar goods are produced, a dobby ranging from 24 up to 36 shafts is adopted, whilst in the fancy dress-goods trade the capacity of the dobby extends up to 48 shafts. The mechanism of dobbies may be divided for comparison into two classes, referred to as the wheel dobby and the lever dobby, of which the Hollingworth and Knowles and the Keighley dobbies are typical examples. The former class until recently has been the exclusive production of the Dobcross loom makers. It has now, however, a rival, in a new loom made by Messrs George Hodgson Limited, Bradford, who have introduced this principle of shedding in their loom. The "Keighley" dobby, the invention of Messrs Hatters-

ley and Sons, is now made in various forms by several well-known dobby and loom makers.

An illustration of the principle parts in the Hollingworth and Knowles dobby is shown in side elevation in Fig. 25. The healds are connected to the jack J as follows: From the upper arm J^1 connection is made to the top of the heald shaft by means of streamer wires and straps which are carried over heald pulleys. The heald shaft is connected from the bottom by means of underjacks and streamer rods up to the lower arm J^2 of the jack. The jacks are made with an open bearing, which admits of their easy removal, and are provided with notches into which the connecting links are placed, according to the depth of shed required and the position the heald shaft occupies in the set of healds. To increase the facility for obtaining a gradually sloping shed in a 36-heald dobby, the jacks are made in three sizes, 12 jacks of each size. This provides ample scope for adjusting the stroke of the heald shafts farthest away from the fell of the cloth, there being a range of 17 notches from the first notch in the shortest jack to the last notch in the longest jack. The jack is provided with a knuckle joint at J^3, on which fits the forked end of the connector C; the other end of the connector is also made with an opening to admit the vibrator V, to which it is pivoted. The vibrator is a toothed disc with the teeth arranged in the order: 17 teeth, then one tooth missed, 17 teeth, then four teeth missed. It is also provided with a radial slot S, the extremity of which comes in contact with a bowl U fixed in the lever H, the purpose of which is to arrest the vibrator in the same relative position after being turned over in either direction. The vibrator is supported at its centre T on a bowl in the vibrator lever, which is provided with an aperture for this purpose. A pulley slip or shoe is fixed in the

lever under which the pulleys on the pattern chain pass, the chain being arranged around the lag cylinder L. The lever H is supported at the heel on the shaft P, and held in a vertical position by the grids O and Q. The vibrator is operated by the fluted cylinders A and B, commonly termed " chills," one being placed above and the other below the vibrator. These cylinders have 19 teeth (covering exactly half their circumference), and are

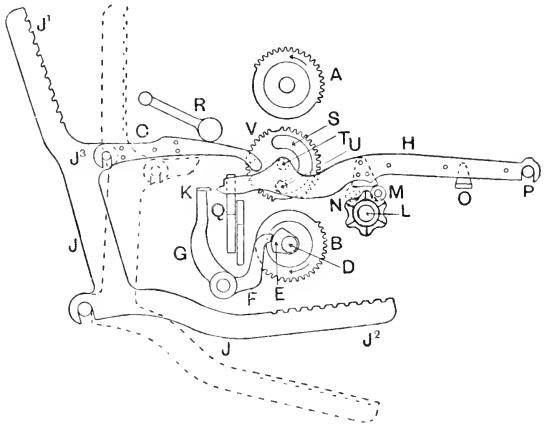


FIG. 25.

driven in opposite directions, as indicated by the arrows; the top cylinder lifts, and the bottom cylinder lowers, the healds.

The lock-knife is an essential part of this dobby, and consists of a blade K which extends the full width of the vibrator levers. It is fixed to the top of the arms G, which are actuated by the cam E on the bottom cylinder shaft D by means of the finger F. The function of the knife is to keep the vibrators in gear with the respective cylinders A and B during the time they are being turned

to lift or lower the heald shafts. The knife works away from the tongues of the vibrators to allow another lag to come under the pulley slips, and again re-enters to lock them in position. The connector weight R is employed to press down the connector attached to any vibrator which through some cause has not been completely turned.

Tracing out the method of working, let it be assumed that the heald shaft is down and the position of the various parts is as shown in Fig. 25. It will be observed that the space in the vibrator where one tooth is missed is opposite the top cylinder A; the vibrator is being lifted up into position by reason of the pulley M on the pattern chain passing under the shoe, while the lock-knife is withdrawn to enter again into the cleft of the vibrators immediately they are fully changed. The reason for the omission of one tooth will now be evident —*i.e.*, that it ensures the first tooth of the cylinder A entering this space to turn the vibrator over, and not to strike the top of a tooth, which would be possible if the vibrator, through any cause, had not been turned completely. The motion is transmitted from the vibrator to the heald shaft; the space where four teeth are missed on the vibrator now comes opposite to the top cylinder. No further movement can take place so long as a succession of pulleys are placed on the pattern chain to keep the vibrator elevated. When the heald is required to be lowered, a bush is substituted for a pulley. This allows the lever and vibrator to drop; then, as the bottom cylinder comes round, the first tooth enters the space where one tooth is missed, turning it over so that the heald shaft is made to resume its former position. The heald will remain down as long as a succession of bushes are placed on the pattern chain.

The space in the vibrator where four teeth are missed

is always left opposite the cylinder by which it was last turned. The style of shed produced is the "open shed," due to the healds remaining up or down for the requisite number of picks, a factor which facilitates high speeds being attained.

TIMING AND SETTING.—The successful working of this dobby is dependent upon the judicious timing of the various parts in relation to each other. One of the special advantages of this dobby is that which affords a ready means for timing the shedding motion to the beat-up, for reasons already stated. This is accomplished by setting the cylinders A and B, which control the healds, from being level with the box section, or as many as seven teeth in advance of it, according to requirements. It is the usual practice to set the heald section five teeth in advance of the box section, and allow them to remain in that position for all classes of work. This is a questionable practice, and unless early shedding is resorted to for the purpose of clearing the shed (*see* page 58), the following setting should be adopted. Set the heald section in line with the box section for light work, four teeth in advance for medium work, and seven teeth in advance of box section for heavy work, which is the maximum. When setting the cylinders it is important to have the first tooth of each engaging with respective vibrators exactly at the same time. The limitation of setting is governed by the shape or throw of the cam E. It is obvious that the lock-knife must remain in contact with the vibrator levers until the vibrators in both the heald and box sections are completely turned. This time will be equal to half a revolution of the cylinders when they are set level, or two-thirds if set seven teeth in advance; therefore the dimensions of the cam must be made to correspond with this latter setting. This leaves the minimum

time for the lock-knife to move out and in again to allow the next lag to come into position under the pulley slips.

Fig. 25 illustrates the relative positions of the various parts when the heald section is set four teeth in advance of the box section. The vibrator is shown half-way lifted, the pulley on the pattern chain just passing under the shoe, and the dotted pulley N leaving the shoe. The lock-knife is fully out and in the centre of its movement, with the finger F in the middle of the throw of the cam. The cylinders are set to follow the lock-knife—*i.e.*, as the lock-knife re-enters the cleft between the raised and lowered vibrators, the cylinders A and B would have revolved and be nearly touching the teeth of those vibrators to be turned, as indicated by the pattern chain.

The several parts of the dobby which are subject to strain and wear have received special consideration in their construction. The cylinders are chilled; the vibrators are made of steel with machine-cut teeth. The vibrator and connector being supported by bowls and not on an ordinary rivet, have a considerably increased wearing surface and consequently are much more rigid. This fact should be borne in mind when the vibrators, etc., are being repaired. After the vibrator has been placed in the lever, *right side up*, the rivets should be driven lightly into the bowl, and then riveted to prevent any possible chance of the bowl or the rivet rotating; and similarly when attaching the connector to the vibrator. This method of construction, combined with a sufficient oil supply to the various parts, yields a high percentage of working efficiency.

The method of driving the various parts of the Hollingworth and Knowles dobby is illustrated in side elevation in Fig. 26. The upright shaft A is driven from the end of the crankshaft B by the spur and bevel wheels

C, D, E, and F. The spur wheels C and D are occasionally made slightly eccentric, to yield additional harmonic motion to the healds and boxes during their change. The bevel wheel F forms part of a clutch box, the purpose of which is to provide a ready method of discon-

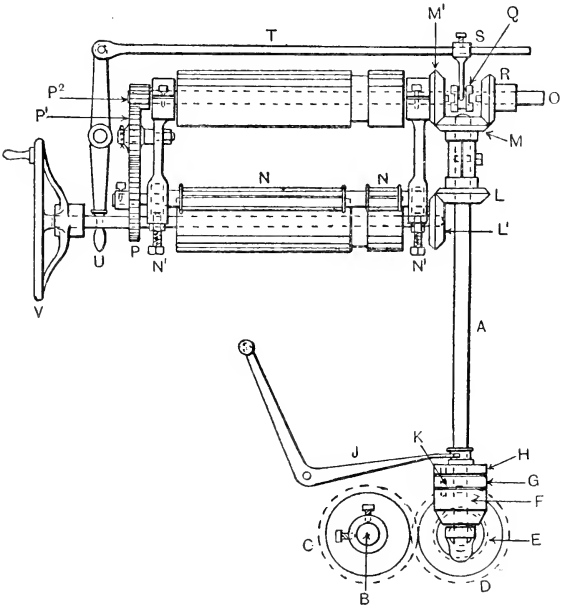


FIG. 26.

necting the dobby mechanism from the rest of the loom to allow the healds to be brought level or the action of the dobby reversed. The clutch box consists of three parts —namely, the clutch-box bevel F, the centre portion G, and the top part H. The bevel wheel F is driven from the bevel wheel E, and is free to rotate on the upright

shaft whenever the top part H is raised. The centre portion is secured firmly to the shaft. The top part of the clutch is so constructed that it can be moved in a vertical direction on the upright shaft, and it is manipulated by means of the lever J, which extends towards the front of the loom, and is easily accessible to the weaver. This portion of the clutch box is fitted with a stud K which passes through the centre portion, and when in the working position enters a hole in the top of the clutch-box bevel H. The three parts are firmly coupled together so that when the loom is started motion is transmitted through the upright shaft to the dobby. Two bevel wheels L and M are fixed at the top of the upright shaft. These bevels being in an inverted position in relation to each other, drive the wheels L^1 and M^1 in opposite directions, and also the top and bottom cylinders to which the wheels are secured.

The top and bottom cylinders may be set in correct relation to each other as follows: The upright shaft is first drawn out of gear with both the bevels L^1 and M^1; the cylinders are then set to engage with their respective vibrators exactly at the same time. The upright shaft is then placed back in position. Care must be taken to see that the plug and half-tooth of the bevels L and L^1 found on some looms are in correct gear with each other. An alternative method is first to place the bevels L and L^1 in correct gear, and then set the top cylinder to the bottom one by taking off the caps of the top cylinder and lifting the bevels M and M^1 clear of each other, so that the two cylinders can be then set to work in unison.

The dobby is timed to the beat-up as follows: The spur wheel C is first unfastened, then with the clutch box in gear and the loom turned with the crank to the front centre—*i.e.*, with the reed touching the cloth—the dobby is turned until the vibrators of the box section (not the

heald section) are exactly in the centre of their movement—*i.e.*, if the boxes are being lifted or lowered they will have moved through half their traverse.

It is important to notice whether the boxes are making a single, double, or treble move, the spur wheel C being again secured with the dobby in this position. An alternative method to the above is to turn the going part until the jammers are in contact with the knocking-off frog, and then to set the boxes to have moved $\frac{1}{4}$in., which yields the same result as the setting given above —namely, the boxes would be about half-way changed at the beat-up. It is sometimes the practice to spring the wheels E and F when setting the dobby, instead of loosening the spur-wheel C. This should not be tolerated, as there is a considerable risk of straining the shaft or of stripping the teeth.

The lag cylinder is driven by means of the spur-wheels P, P^1, P^2, from the end of the shaft O, which runs through the top cylinder. The intermediate wheel P^1 conveys motion from the pinion wheel P^2 to the lag cylinder wheel P. This latter wheel is secured to the shaft by means of a set-screw, which is specially constructed with a soft end, to serve as an escape motion in the event of the lag cylinder becoming locked through any cause. The end of the screw is not threaded for $\frac{1}{4}$in.; this end is fitted into a hole bored into the lag cylinder shaft. If the lags ride or become fast on the lugs of the cylinder so that they cannot pass freely underneath the pulley slips, the soft end of the screw would shear off and allow the wheel P to rotate on the shaft. There are various defects which cause gathering of the lags—*e.g.*, strained lag rods, strained cylinder blades, tight links due to the links being crossed—that is, one end of the link being outside on one rod and inside on the other (this is a very common defect), twisted cotter-pins, and tight bowls or

bushes. When weaving a pattern which requires only a small number of lags (say 8, 10, or 12), it is advisable to peg and use twice the required number of lags; this prevents the lags from gathering owing to the increased weight, whilst the lag roller and chain carrier may also be used.

The shaft O is driven by means of the bevel clutch Q, which is provided with a saddle key that fits into a key-way cut in the shaft. The clutch is made with two recesses, to gear with corresponding projections on the bevel wheels M^1 and R, between which it is fitted, and can be moved in a lateral direction, but cannot rotate without the shaft. The clutch is controlled by means of the clutch fork S fixed on the rod T, this latter being operated by the reversing lever U placed at the front of the dobby. With the clutch in gear with the bevel M^1, the shaft O and the pattern chain cylinder will revolve in the forward direction, bringing the pattern lags and the box chain into position. When it is necessary to reverse the lag cylinder in order to open and take out the weft when remedying some defect in the piece, the clutch is transferred to the reversing bevel R. This latter being driven from the bevel wheel M, revolves in an opposite direction to M^1, with the result that the shaft O and also the lag cylinder are reversed. Some care is necessary when setting the reversing bevel R. When it is required to transfer the clutch, the dobby is first disconnected at the clutch box; then by means of the hand-wheel V the dobby is turned until the lock-knife finger is in the middle of the throw of the cam. When in this position the projections on the bevels and the recesses of the clutch should be in a straight line so that the clutch may pass freely from one part of the shaft to the other. It is possible, however, to set the reversing bevel so as to give an advantageous lead to the lag cylinder when reversing.

The lag cylinder can be easily set to correct time with relation to the lock-knife by drawing the carrier wheel P^1 out of gear, and so leave the lag cylinder free to be turned into position in either direction. Equal in importance to the timing is the setting. The position of the lags on the cylinder should be such that the pulleys pass directly under the pulley slips. This position is obtained by means of the set-screws N^1, which support and secure the journals in which the cylinder shaft is carried. An important factor in setting the lag cylinder is its height. If it is set too high the pulleys on the pattern and box chains would lift the vibrators too deep in gear with the top cylinder; in which case, in addition to unnecessary friction, the dobby could not work satisfactorily.

A very useful accessory to this dobby is the levelling lever. This enables the healds to be lifted to one common level for the purpose of repairing broken ends, heald cords, etc. The lever rests underneath the tongues of the vibrator levers, and is provided with two inclined slots, supported on two pins fixed in the vibrator lever grid. As the lever is drawn outwards it rises to a higher level, and so lifts up all those vibrator levers that are down. In effect this is equal to placing pulleys on the pattern chain to come under each pulley slip; the dobby is disconnected and the hand-wheel is turned one revolution, and the top cylinder simultaneously lifts up those healds that are down. The hand-wheel is now turned back one revolution, which takes the lag cylinder back to its former position; then, when the loom is restarted it will form the proper shed and give the correct pick. This latter advantage is obtained on account of the pattern chain, box chain, and the picking being worked from the same shaft, and is an essential feature in all such looms.

THE HARMONIC MOTION OF THE HEALD. — Another feature of this dobby is found in the nature of the "harmonic" movement imparted to the healds. This is a desirable factor in all shedding motions, as with such a movement a gentle action is imparted to the warp, with the attendant advantage of fewer broken threads and heald cords. In Fig. 27 the circle H represents the vibrator to which the connector is secured. The path of the connector bowl, which travels slightly more than a semicircle, is indicated at A, G, and F. The lateral distance is represented on the scale A F, marked in eighths of an inch. Taking five equal distances around the semicircle, and dropping perpendiculars to the scale line, the distances travelled in equal angular spaces are obtained. Observation shows that the distances A B, E F at the commencement and finish of the movement are considerably less than the distances shown at B C, C D, D E. The movement of the healds takes place in the same relative proportions—*i.e.*, they commence to change slowly, increasing in the centre of their stroke, again diminishing towards the finish.

JACK-MISSINGS.—A defect incidental to all dobby mechanism is "jack-missings"—*i.e.*, the heald shaft remaining up when it should be down, or *vice versa*; or, as is occasionally experienced, the heald shaft only being moved through part of its stroke. In the dobby under discussion the defect may be due to any of the following causes: Strained lags, a result of the pattern chain gathering on the cylinder; broken or snipped pulleys on the pattern chain, which work up the side of the vibrator shoe instead of lifting it; the lock-knife not being set in tune with the top and bottom cylinders—*e.g.*, the lock-knife may be leaving the tongues of the vibrator levers before the vibrators are completely turned. The result of this would be that the vibrators

would slip out of gear with the cylinders, and allow the heald shafts to spring back towards the centre of their stroke. This effect would produce "stitching or scobbing," on account of the shed being imperfectly formed, and probably would cause the shuttle to be thrown out of the loom. Other causes of jack-missings

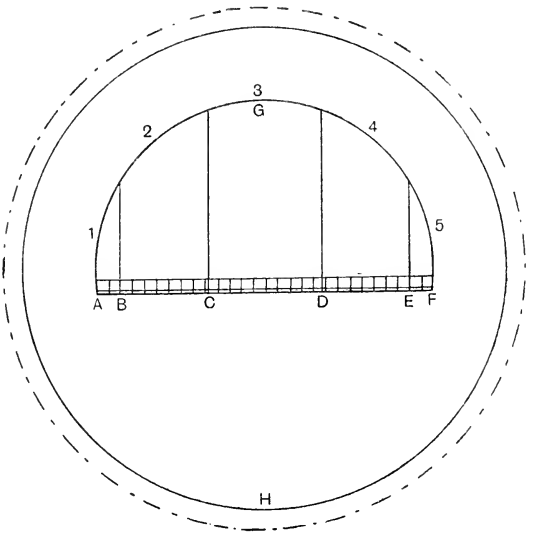


FIG. 27.

are that the lag cylinder is out of tune as regards either time or position, and worn and defective parts. It is a common practice when weavers are dropping the healds in order to check the warping plan to use a weft bobbin to push the vibrators over; frequently the bobbins split, leaving a portion of the wood among the vibrators, which, when the loom is started, can have only one result.

The missing of jacks may be occurring on any or all of the healds; this is soon in evidence in the woven fabric, and denotes that the mechanism generally needs overhauling. If, however, the defect is only produced by one heald shaft, it may either at regular intervals, or of one repeat of the pattern chain, or at irregular intervals in the piece. The best method of dealing with such defects is to trace out the floating thread of warp and follow it to the healds to ascertain on which heald shaft it is drawn. The parts controlling that particular shaft may then be carefully examined and overhauled.

Lever Dobby.—It may be safely asserted that dobbies built on the lever principle are far more numerous than wheel dobbies. This is easily accounted for by the fact that there are so many different makers producing their own specialities of lever dobbies. A very simple style of lever dobby, and one extensively used, is known as the "double-lift" with negative action. Such a dobby is constructed with two lifting knives, for operating the draw hooks which control the jacks and impart motion to the heald shaft. This mechanism actuates the heald shaft in one direction only—*i.e.*, lifts the shafts; a reversing motion being necessary to draw back the shaft to its former position. The style of shed produced is the open-shed, the heald shafts being kept elevated for the requisite number of picks. The negative action of such dobbies renders them unsuitable for weaving heavy goods, as with such cloths considerably more power must be applied to the heald shafts, in order to keep the warp on the race and prevent it from being lifted by the excessive tension applied when shedding. The result of this would be that the shuttle would be impeded in its course if not thrown off the race. To enable such dobbies to be employed for heavy goods, a very powerful reversing motion is necessary. Occasionally the number of springs

is doubled—*i.e.*, two or more springs are attached to the heald shafts. Such a conventional method can only result in more power being expended in the formation of the shed. The worst feature of negative shedding is revealed when weaving cloths composed of uneven sheds —*e.g.*, backed or double cloths; some sheds have few shafts lifted, while the succeeding pick may have considerably more. The outcome of this is that the springs oppose the working of the loom when the shed is being formed, and work with the loom when the shed is closing, yielding very unsteady running. Another disadvantage of such dobbies is the absence of any provision for reversing the dobby, also the take-up motion, when the weaver has occasion to pick back for any defect. The lag cylinder in such dobbies is usually operated from the bottom lifting knife during its forward stroke, by means of a catch actuating the ratchet wheel. This latter is made with six or eight teeth, according to the form of the lag cylinder, and is fitted to the end of the cylinder shaft. The pattern lags in such a form of dobby are constructed with a double row of holes, the first row being pegged to indicate for the odd picks of the weave, the back row being pegged for the even picks. This arrangement is undesirable because of the small space available in which the tumblers and needles have to work. A further disadvantage is met with in this type of dobby in the short dwell imparted to the healds to allow for the passage of the shuttle. The lifting knives are invariably operated from the low shaft of the loom by means of a crank and connecting rod, so that only such time as it takes the crank to pass the top and bottom centres is allowed for the passage of the shuttle.

The following is a summary of the various causes of " jack-missings " in this type of dobby: (*a*) It is essential when connecting the lags to fasten them together so that

each lag is equidistant apart, otherwise they are liable to ride on the cylinder and not pass freely under the tumblers; or if they do pass forward, the edge of the lag will lift up all or part of the tumblers and give a wrong shed. Rings should be used for connecting the lags together, and not string. (*b*) Needles sticking. To avoid this, keep the parts free from grease, and use a good quality of oil. (*c*) If wood pegs are used they occasionally become bruised, resulting in the top of the peg being broader, and so tending to lift up the adjoining tumbler. (*d*) Beware of broken or short pegs, also of pegs dropping out. (*e*) Draw hooks slipping off the knife when midway in their stroke. (*f*) The lag cylinder not in correct position with the tumblers. (*g*) The most important feature in the type of dobby illustrated in Fig. 28 is the timing of the lag cylinder in relation to the lifting knives. The cylinder should be timed to bring the next lag into position just before the lifting knives reach the extremity of their stroke. This would then allow any of the hooks to drop on to the knives where a peg had been inserted in the pattern chain, or allow such hooks to be lifted off the knives, where a blank follows a peg, so that the top sneck of the draw hook may come in contact with the retaining bars. It is also of the utmost importance that the stroke given to the knives and lowering bars, as well as the position of the retaining bars, should be such as will allow the hooks to be lowered or lifted quite freely, and be quite clear at the time when they are changing positions.

Hattersley Double-action Open-shed Dobby.—A more modern form of this type of dobby is illustrated in front elevation, in Fig. 28. This dobby is constructed on the double-action principle, yielding a positive motion to the healds, producing an open shed. The healds are connected from the top to the upper arm of the jack A ,

and from the bottom by means of streamers and levers to the lower arm. The jack is supported at the open bearing on the shaft A^1, and is further provided with the stud A^2, to accommodate the baulk lever by which it is operated. The baulk lever B is in turn actuated by means of the draw hooks C and D, which are connected to the top and bottom of the baulk lever by knuckle joints. The draw hooks are made with snecks at points C^1 and C^2, also at D^1 and D^2. The hooks are placed in such a position as to be readily put into contact with the lifting knives E and F. This is accomplished through the medium of the needle N shown in end elevation at N^1, on which the draw hooks rest. The needle receives indication from the tumbler T according as a peg or blank is left in the pattern lag. The guides in which the lifting knives and lowering bars work are inclined at such an angle that the draw hooks work more in line with the arcs of circles described by the upper and lower ends of the baulk lever. The advantage accruing from such an arrangement is that the hooks, being drawn more directly in the line of resistance, perform the work with considerably less friction, and are more certain in their action. To lower the heald shaft two lowering levers H and J are employed. These are coupled to the lifting knives by rigid connecting bars (not shown in the drawing), these in turn being attached to the draw bolts V and V^1. To aid in the lowering of the shaft, two retaining bars G and G^1 are necessary, with which the top snecks of the draw hooks engage.

Fig. 28 shows the heald shaft at its lowest point, the top lifting knife and lowering bar being in their backward position, and the bottom knife and lowering bar in their forward position. A peg P having come under the tumbler T, causes this latter to be lifted at the outer end, so lowering the needle N. The support of the draw hooks

being withdrawn, they drop immediately they are released at the retaining catch. The top hook falls and rests on the knife E; the bottom hook falls with the sneck D^1 directly behind the bottom knife F. At the next movement of the lifting knives the bottom draw hook will be drawn back, and with it the baulk lever B, which is prevented from working forward at the top by reason of the fixed bar K. This allows the jack to be pulled over on its fulcrum and so lift the shaft. If the heald is required to be lifted for more than one pick in succession, another peg would have to be placed in the next lag, and so permit the top hook to drop on to the top knife E, which has now moved to its forward position. The action which is now taking place is simply that the baulk lever is turning on its fulcrum A^2, keeping the heald shaft elevated so long as a succession of pegs are placed in the pattern lags to keep up the tumbler T.

Assuming that the heald requires to be lifted for one pick only, then, as the knives and lowering bars approach the end of their stroke, another lag is brought into position, and as a result of there being no peg to support the tumbler it falls by reason of its own weight, lifting up the needle and the draw hook at the same time. The sneck C^2 of the top draw hook now comes into contact with the retaining bar G, preventing it from moving backward, whilst the bottom lowering bar J, which is now returning to its forward position, presses against the lower end of the baulk lever, and at the same time carries the jack and heald shaft to their bottom position. With a succession of blanks in the pattern lags the snecks C^2 and D^2 of the top and bottom draw hooks keep in contact with the retaining bars G and G^1. This prevents the heald shaft from being lifted from the level of the bottom shed line by the tension of the warp threads. Motion is imparted

to the lifting knives and lowering bars from the arms L^1 and L^2 of the lever L, to which they are connected by means of the draw bolts V and V^1. The upright driving rod R is connected at the top to the arm L^3 of the lever L, and at the bottom to a stud in the driving wheel M.

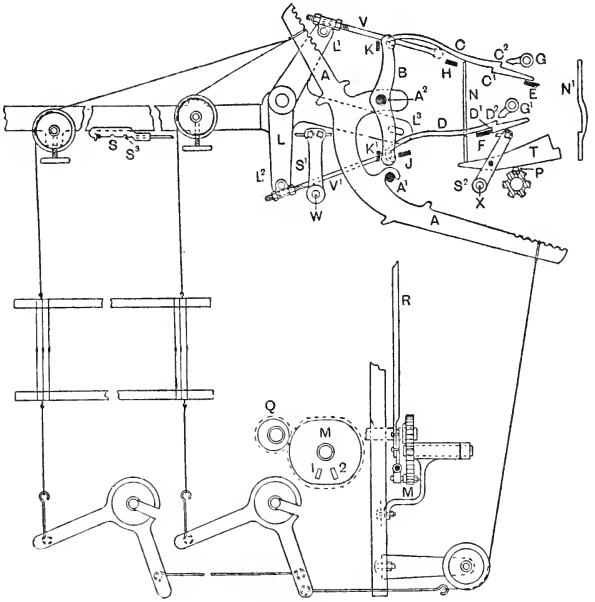


FIG. 28.

This wheel is in turn driven by the wheel Q fixed to the bottom shaft of the loom. With the object of allowing more time for the passage of the shuttle, a dwell is given to the dobby when the crankshaft is turning about the back centre. This is accomplished by making the wheels M and Q slightly elliptical—*i.e.*, the wheel Q is eccentrically set, and this being half the size of the wheel M,

necessitates this being elliptical in shape, as shown in end elevation.

Harmonic motion in this and similar types of dobbies is obtained from the nature of the mechanism employed for operating the dobby. This is usually performed by coupling the driving rod R to a crank fixed on the end of the low shaft, or as shown in Fig. 28. An advantage is claimed for this type of dobby owing to the reciprocating motion of the lifting knives, as the dobby mechanism thus only runs at half the speed of the loom, and is therefore steadier in action and attended with less friction.

Provision is made in this type of loom for timing the shedding motion to the beat-up by introducing two stud holes 1 and 2 in the wheel M. The stud can be fixed into either hole as required. One would give the earliest position for shedding, the other the latest, no intermediate position being available. To reverse the pattern and box chains, which in this loom are worked from the same cylinder, the rod S is employed. This rod is attached to the brackets S^1 and S^2 fitted to the shafts W and X respectively. The shaft W is suitably connected to the fork lever which indicates the side of the loom from which the pick will take place. The shaft X is connected to the reversing clutch on the take-up shaft, from which the lag cylinder is driven. When the reversing lever is transferred to the middle position, the picking is rendered inoperative, but the lag cylinder and take-up motion continue to move forward as the loom is turned over. To reverse the direction of the lag cylinder and take-up motion, the rod is transferred to the position marked S^3. To take out the picks the loom has to be turned over for each pick withdrawn. The experienced weaver can take out the picks as quickly in this loom as is possible in looms where the dobby mechanism is operated by hand for this purpose.

The two styles of dobbies already considered show in detail the principles underlying the construction of modern dobby mechanism. It is not intended to give any further consideration to these types, since most other dobbies can be compared in detail with those described, and conclusions drawn as to the merits of one dobby or system over another.

Centre Closed-shed Dobby.—This type of dobby varies from the two former in the style of shed produced. It is essentially a lever dobby, but is constructed to give a centre closed shed. The healds are all brought to one common level after the insertion of each pick. To form the shed some healds are lifted, and the remainder drawn down to form the top and bottom shed lines respectively. When a heald shaft is to be lifted for more than one pick in succession, it must return to the centre to be again lifted for the next pick, and similarly for the shafts that are to be down. This style of shedding mechanism imparts considerably more movement to the warp threads than is the case in open-shed dobbies; this factor is responsible for the increased driving power required for such dobbies. The loom cannot be run at so high a rate of speed as is possible with the open-shed dobby, for the motion given to the healds results in more wear and friction between the parts. These are no doubt the chief reasons why this type of dobby is not more extensively employed, as this system of shedding does possess certain advantages not found in open shedding.

Cross Border Dobby.—This is an ordinary type of dobby to which certain mechanism has been added as an accessory for obtaining a special result. Such a dobby facilitates the production of bordered fabrics—namely, towels, shawls, table-covers, etc. In some dobbies this is accomplished by employing two pattern chain cylinders, one cylinder being used for the ground of the fabric, or

the edges and centre, the other cylinder being used for the borders (weft way) of the fabric. Either of these two cylinders may be put into operation by receiving indication from a third cylinder, by which they are controlled, according to the number of repeats required of each to form the edge, border, or centre of the fabric. Such mechanism is entirely automatic in its action. Another method is to employ one lag cylinder only, which is driven in such a way as to pass two pattern lags forward at each pick. With this mechanism the respective designs for the centre and borders of the fabric would be pegged as follows:—The design for the centre and edges, which are invariably the same pattern, would be pegged on the odd-numbered lags, the design for the border on the even-numbered lags. When the requisite number of repeats for the edge or border have been completed, the lags are turned one lag backward or forward to bring the alternate pattern lags into operation. With this mechanism the changes are dependent upon the weaver. The former is the most common principle, and is chiefly employed on lever dobbies for weaving the class of fabrics named.

Defective Shedding.—That there are defects in cloth caused by imperfect shedding, other than those due to "jack-missings," is well known. These may be summarised as follows:—

Reediness in Cloth.—There are certain fabrics which require to have all traces of reed marks entirely obliterated, the object being to give to the fabric an appearance of fullness and density, or what is usually spoken of as "cover." As examples of this, plain calico, also union cloths in which the warp is cotton and the weft woollen, worsted, or angola, may be cited. Usually the latter class of cloth is woven in plain weave with such a number of picks per inch and the weft of such a count that the

cotton warp will be completely hidden by the weft. These results are best obtained by troughing the shed, though this practice is to deviate somewhat from the formation of a perfect shed. A perfectly-formed shed is understood to be one in which the top and bottom shed lines of warp are equal distances from the warp line. The warp line is the position taken up by a tensioned cord when passed over the back roller and the piece beam. It is evident that when the top and bottom shed lines are drawn equal distances from the warp line the tension on each will be the same. Under such conditions the threads will work in groups as they are passed through the reed, showing the position of the reed marks quite distinctly, and giving to the piece a raw and lean appearance. Troughing the shed consists in adjusting the position of the back roller and piece beam, chiefly by raising the back roller, so that the bottom shed line of warp is depressed more below the warp line than the top shed line is raised above it. The result is that greater tension is applied to the threads when at the bottom shed line than when forming the top shed, as when in this position they are practically free from tension. When troughing the shed is resorted to for the purpose of obtaining cover on a cloth, the alternate tightening and slackening of the threads, as they form part of the bottom and top shed lines, imparts to them a reciprocating motion. This movement of the warp threads, as they are intersected with the weft, will naturally cause them to work towards the point of least resistance—*i.e.*, to the centre of the long weft float caused by the reed wire. In addition to the threads being more equally distributed, the shrinkage of the warp and the weft will be more uniform, giving better cover to the fabric.

The operation of troughing the shed has also a decided effect on the twill of a cloth. Observations on the

results of experiments made in this direction, also from practical experience, prove that the twill is more pronounced in a cloth woven with a troughed shed. In a cloth woven without the shed being troughed, the weave being a 2-and-2 twill, the warp black cotton dented 12 reed 4's, and the weft white worsted, every fourth pick had the appearance of intersecting 1-and-1 instead of 2-and-2. This was entirely due to the reed splitting the first and fourth threads, and thus the continuity of the twill appeared broken. This defect entirely disappeared after the shed was troughed. Another instance occurred in which the twill was more pronounced in the first part of the piece than in the latter part. The piece had been woven in a loom in which the back roller bracket was provided with two bearings, a higher and a lower, into either of which the back roller could be placed according to the wefting requirements. It was proved that the first part of the piece had been woven with the roller in the top bearing, giving a troughed shed; for weighting the warp the roller was then transferred into the low bearing, which had the effect of tightening the top shed line. The piece being finished "*clean cut*," the difference in the twill of the two portions was revealed in a marked degree.

Uneven Shedding.—The healds should be hung quite level and adjusted for the stroke according to their position in the gear, otherwise this may be the cause of certain common defects. One of these is for the piece to contain cracks or lines running inwards from the selvage of the piece and diminishing towards the centre. Such a defect is most noticeable in fabrics made from yarns of contrasting colours in warp and weft. This kind of defect is brought about by reason of one or more of the heald shafts not working level—*i.e.*, one side of the heald being higher or lower than the other side. The

result is that the shaft in question is simply forming a troughed shed on one side; this produces a crack weft way in the piece each time the shaft is drawn down, which gradually runs out towards the centre of the piece, where the heald assumes its normal position. A similar defect running the full width of the piece is produced in light wefted fabrics, when any of the heald shafts are drawn too far below the warp line.

Badly-formed Selvages may be due to an uneven shed. The threads drawn through the heald shaft which is not lifted to its proper level will hang slack in the shed; the slackest threads being nearest the list will prevent the weft from drawing up tight, giving to the piece an unsightly appearance and a less marketable value.

Weft Staplings are also traceable to an imperfectly-formed shed, especially in certain cloths—*e.g.*, corkscrews, cords, and cloths with a large number of threads per inch. If the shed is not clear, the weft comes in contact with the hanging threads, and is drawn into a small loop at the beat-up, or such threads that hang loosely in the shed may be caught and broken by the passing shuttle.

Depth of Shed and its Effect on the Warp.—This is a factor in connection with shedding which should receive special consideration at the hands of the tuner. Too deep a shed is responsible for unnecessary breakage of the warp threads. The nature of the materials used, and also the construction of the shedding mechanism, impose restrictions on the size of the shed and the result desired. It is desirable when weaving low woollens to employ as large a shuttle as possible in order to use a weft spool containing the maximum length of yarn, with the object of reducing shuttle-changing to the minimum. The larger the shuttle, the deeper the shed required, but this would be limited by the strength of the warp yarn.

If the strain imposed is in excess of the elasticity of the yarn, more time would be lost in repairing the broken threads than would be gained by increasing the dimensions of the spool and the shuttle. The mechanism of a dobby imposes limitations on the depth of shed that could be obtained. Dobbies containing 24 and 36 jacks are largely employed in fancy woollen and worsted weaving. Between the first and last heald shafts there will be a distance of from 10 to 15in., so that the maximum depth of shed and size of shuttle will be determined by the possible stroke of the back heald shaft.

PERFECT SLOPE OF SHED.—To obtain a perfectly sloping shed it is evident that the further the healds are from the fell of the cloth their stroke must be increased in proportion to their position. The threads which are drawn on the back shafts will be subjected to considerably more tension, as they are lifted and depressed more out of the warp line than those drawn on the front shafts. The material might sustain the tension applied by the front shafts, but would be altogether inadequate for the tension applied by the back shafts. It is on this account occasionally advisable to resort to drafting the gear when possible—taking, for example, a warp backed, or a double, cloth, in which one set of the warp threads is made from a different material, as worsted for the face and cotton for the back of the fabric, or they may be made of the same materials but different qualities. The set of threads least capable of resisting the tension should be drawn into the front healds, if the structure of the design renders this possible. The principle of drafting may also be employed for the purpose of assisting to clear the shed. For instance, take a fabric made from coarse fibrous yarn with which it is difficult to clear the shed. The weave is the 4-and-4 twill, straight draft on 8 shafts. Clearing the shed may be facilitated by

drawing the gear to a satin draft, and rearranging the peg plan to give a straight twill.

Easing the Strain on the Dobby Mechanism.—With the object of easing the shedding mechanism when weaving certain cloths, the following methods are adopted. With cloths containing a large number of ends per inch, but for which the weave is complete on a small number of shafts, it is customary to employ twice the number of heald shafts, in order to distribute the strain over a greater number of the jacks. This principle is also applicable to heavily wefted cloths, which for the above reason are more easily woven on double the number of heald shafts. An alternative method sometimes practised in heavily wefted goods is to connect one heald shaft to two jacks, and alter the pegging plan to suit the arrangement. A principle sometimes adopted in relation to the weaving of rugs, shawls, etc., the designs of which are invariably double and in some instances treble weaves, is to arrange the wefting plan so as to minimise heavy changes of the healds. In double cloths arranged one end and pick of face to one end and pick of backing, and which require 12 heald shafts or upwards to weave them, the warp may be arranged one end of face to one end of back, but the weft two picks of face and two picks of backing. This would cause two light sheds to follow each other, then two heavy sheds, in place of a light and heavy shed alternately. Treble cloth designs could be arranged one end of face, one end of centre, and one end of backing in the warp, the weft to be arranged as follows:—

One pick of the face cloth.
,, ,, centre cloth.
,, ,, backing cloth.
,, ,, backing cloth.
,, ,, centre cloth.
,, ,, face cloth.

This would bring two light sheds for the face together, preceded and followed by a centre cloth shed, which would require all the face shafts lifted and all the backing shafts down, except those used for stitching. The changes to and from the heavy backing sheds are thus introduced with less strain on the shedding mechanism.

CHAPTER V

PICKING MECHANISM

THIS motion demands considerable time and attention from the tuner. Not only does the motion require careful attention, but in the hands of the competent tuner, much more the incompetent, it is the chief source of expense due to repairs and renewals of pickers, shuttles, check and other strappings. In short, the picking motion is capable of increasing or decreasing to a great extent the utility and earning capacity of a loom. This will be better understood by taking into account the following factors which are common to all picking mechanism:—

(*a*) The action of all picking motions is practically a negative one. The force of the pick is expended on the shuttle, thus driving it out of the box. The shuttle is then left to travel across the race through the open shed under no control except the contact it makes with the race and the reed.

(*b*) The movement of the shuttle race renders it a matter of great difficulty to prevent the shuttle diverging from a straight course. The pick is timed to take place while the going part is receding towards the back centre. The shuttle will therefore have travelled some distance across the race when the back centre is reached, the race remaining stationary at this point for a short period. The race then commences to move in a forward direction, during such time as the shuttle travels the remaining distance and enters the shuttle-box.

(*c*) The speed at which the shuttle must travel across the race must also be noted. This is calculated to average about 40ft. per second in quick-running looms of various widths—*e.g.*, a loom running at the rate of 100 picks per minute has a reed space of 78in., and the length of the shuttle-box is 18in. The shuttle travels a distance equal to 8ft. at each pick, and assuming that one-third of the revolution of the crank is occupied for the passage of the shuttle, the shuttle will travel 100 × 8ft. in 20 seconds, or an average of 40ft. per second.

(*d*) Checking the shuttle travelling at the above speed in a space of from 3 to 5in. is an operation attended with possibilities that may prove detrimental to the desired result.

(*e*) The tendency for the shuttle to be drawn off the race, on account of the weft passing through the eyelets which are placed at one end of the shuttle, is largely influenced by the amount of tension put on the weft, which varies with the nature of the material used. The lighter the shuttle the greater the possibility of it being drawn off the race.

(*f*) Any variation in the weight of the shuttle used affects the pick. A full or empty spool, and also any slight discrepancy in the sizes of different shuttles, have their effect.

(*g*) Obstructions in the shed may occur at any time, due to broken threads or heald cords, and so cause trouble.

From the above it will be obvious that the picking mechanism may become the source of considerable trouble. In order to make this motion as accurate in its action as possible, the following parts have received special attention—viz., the shuttle, the race, and the nature of the pick to be given to the shuttle, for successful results can only be obtained by these parts being kept in good working condition.

SHUTTLES.—These may be considered as belonging to one of two classes—wheel shuttles and sledge shuttles. The former are not used on modern tappet and dobby looms; they were chiefly employed in the top swing slow loom, a type now rarely made. Such shuttles were exceptionally heavy, being fitted with steel side plates. One feature of this type of shuttle was that the wheels could be fixed at such an angle as to guide the shuttle towards the reed, which reduced to a very appreciable degree the liability of the shuttle to run off the race.

The construction of the sledge shuttle is designed to obtain exactly the same result. To effect this the back of the shuttle is made straight for a greater length than at the front. By this means more surface contact with the shuttle-box back and the reed is obtained. The bevel of the shuttle must coincide with the angle formed by the race and the reed. The shuttle tip is sometimes set slightly to the front and a little below the centre of the shuttle. The object of this arrangement is to enable the shuttle to force its way under any obstruction in the shed, and it is therefore not so easily thrown out. A further advantage obtained from a shuttle made in this way is that a slight bias is given to that side of the shuttle running against the reed. The weight of the shuttle should be such as will best suit the nature of the weft with reference to the drag, whilst the size should be sufficiently large to accommodate the weft cops it is intended to use. Shuttles should be made from special wood, and the tuner will do well to avoid the cheaper makes of shuttles, as these quickly wear up rough, and are liable to split with the momentum and impact when entering the box.

The shuttle and the weft cop may be responsible for the following defects: If the shuttles in a set vary in size and weight the loom will be constantly knocking off, or the shuttle thrown out of the loom; as a result it is

impossible to adapt the pick to suit the different conditions required for a tight, slack, light, or heavy shuttle. The shuttle peg should be held firmly in position to prevent the weft from being broken, or the weft in the different shuttles being unequally tensioned, by bearing on the inside of the shuttle. The bobbin should not project below the shuttle bottom, or the warp, as well as the weft, will be chafed. This latter defect is sometimes the cause of the shuttle flying out of the loom.

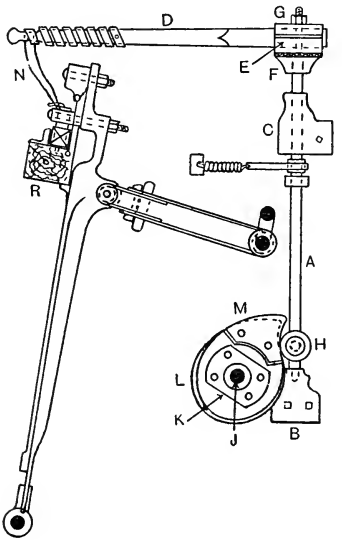


FIG. 29.

THE SHUTTLE-BOX AND ITS INFLUENCE ON THE SHUTTLE.—The construction of the shuttle-box is a factor which exercises considerable influence on the passage of the shuttle. If the shape or the construction of the box is faulty, it naturally follows that the commencement of the passage of the shuttle will also be faulty. Shuttle-boxes are made in various forms owing to the diversity of picking motions employed. Experience proves that the nearer the boxes assume a rectangular form, and are free from swells and the action of their springs, the more efficient are they in their working. In Fig. 30 the plan of such a shuttle-box is shown fixed on a plain loom, single box at each side, or one box at one side and a set of boxes at the other. Such looms are

usually made with a loose reed as warp protector stop-motion, and are therefore free from box swells. The shuttle O is supported on the race R, and is enclosed by the box back and the plate Q which forms the box front. The top of the box is open to admit the picker P. This latter works on the spindle S, and is connected to the picking arm D, that moves in a horizontal plane above the box, hence the name "over-pick." In single-box looms the picker may fit over the picking stick. In this case the stick moves in a groove cut through the box bottom, the fulcrum of the stick in this instance being below the box, hence the name "under-pick." This type of box yields fairly good results, as the shuttle, being enclosed between the two sides and the bottom of the box, is quite free to leave and enter, though a flat spring is sometimes placed in the box to assist in checking the shuttle. A similar form of box is applied to plain fast reed looms, fitted with a stop rod as warp protector. In this instance a box swell is employed to operate the stop rod. The swell projects some distance into the box, and the swell spring being made very strong by reason of the stop-rod arrangement, the excessive pressure of the spring exerts an influence on the shuttle as it is driven out of and enters into the box, unless the loom is provided with a swell easing motion. In rising and drop box looms the picker spindle is placed

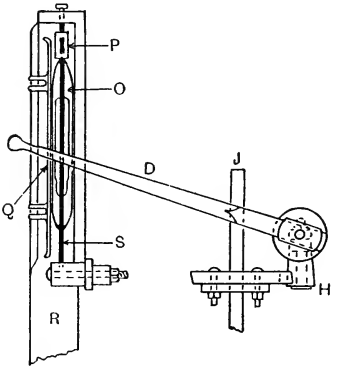


FIG. 30.

either in front of or behind the boxes. When in front the box is formed by turning the box shelf up or down to form the shuttle-box front. In this instance the shuttle is only gripped on about one-third of its depth, the remaining space being required for the working of the picker. Where the picker is placed behind, the back of the box is made with an aperture to accommodate the picker. The box swell in this instance is at the front of the box, and practically takes the place of the box front. Long shuttle-boxes are much better than short boxes in their influence on the picking and checking of the shuttle, though faulty construction may be the cause of that ever-recurring defect, "weft cutting."

The Pick.—The nature of the blow to be imparted to the shuttle should be such as will cause the minimum of vibration on the parts affected. There is no possible means of calculating the actual force required, owing to the many variable circumstances attendant on picking —viz., the frictional resistance between the warp and the shuttle; the pressure exerted on the shuttle when leaving and entering the box; and the friction of the picker on the spindle when newly oiled or when requiring oil. With careful and judicious setting of the parts, however, the picking motion may be adapted to cover a wide range of requirements.

Picking Motions.—Fig. 29 illustrates the most common method of developing the force by which the shuttle is driven across the race. This is a type of an over-pick motion invariably adopted on plain looms giving alternate picking. It is also applied in a modified form to looms in which the pick is required to take place from either side a number of times in succession. The mechanism consists of the upright shaft A supported by the footstep bearing B, and held in position at the top by means of a bottle-neck pedestal C. At the bottom

of the shaft A the anti-friction cone H is placed. At the top of the shaft a clamp is provided to carry the picking stick D. This clamp is made up of two parts or discs E and F, into which radial teeth are cut to ensure a safer grip, and also to provide a means of timing and setting. The picking stick is held by the top part of the clamp, the parts being secured by means of the nut G, the picker being connected to the arm D by the flexible strap N. The cone is carried on the stud, on which it is free to rotate by making contact with the picking tappet. This latter consists of three parts—the boss K, which is keyed fast to the low shaft J; the shell L, which is bolted to the boss; and the picking nose M, which is secured by bolts to the shell. The object of making the tappet in three parts is to allow for setting the tappet in relation to the cone and to facilitate timing of the pick, also to afford a ready method of renewing the tappet nose when it is worn out.

Timing and Setting.—A good method of setting this type of picking motion in relation to the shedding and beating-up, and at the same time to deliver the requisite force to the shuttle, is as follows: Turn the loom so as to bring the crank to the bottom centre. At this point the picking tappet should be in contact with the cone, and have forced it backward until the cone stud is parallel with the low shaft J, and the picking nose about to give the accelerated movement to the cone. The picking stick should have been drawn forward to such an extent as almost to form a right angle with the cone stud, the picking strap being drawn tight and the picker in contact with the shuttle (Figs. 29 and 30). This rule may be adopted on either narrow or broad looms, and will give fairly accurate results.

Defective Picking.—One of the causes of the shuttle not running satisfactorily with such a picking motion as

described is due to the picker coming to rest on the spindle at the entrance to the box, instead of at the back, after the pick has been given. This may be due to faulty setting of the picking stick, or it may be due to imperfect checking of the shuttle. It is advantageous to have the shuttle-box slightly wider at the entrance than at the back, in order to better assist checking and picking. Should the picker be met by the shuttle at the entrance to the box, the probability is that the hole worn in the picker by the shuttle tip will not be in correct position. Consequently, as the shuttle is driven out of the box it will be thrown slightly to one side or the other, either away from, or to bear heavily against, the reed.

Over-pick—Pick-at-will Motion.—The type of picking motion previously considered is operated from the low shaft of the loom, which in this instance runs at half the speed of the crankshaft. With this type of picking mechanism the requisite force can be obtained with a minimum of vibration on the parts affected. The pick cannot be increased to the same extent as is possible in looms where the low shaft is run at the same speed as the crankshaft. Still, sufficient force can be generated by a proper relation in the size and shape of the component parts, which is sufficient for the class of loom to which this type of motion is usually adapted.

Figs. 31 and 32 illustrate, in side and end elevation respectively, a picking motion built on the over-pick principle. In this motion the low shaft carrying the picking tappets is run at the same speed as the crankshaft of the loom. This modification is adopted primarily to allow of the picking taking place from either side at will. Such a feature is essential in looms employed for weaving fancy fabrics, in which odd picks of a colour or of a different quality of yarn are put into the cloth. Obviously the picking tappets must revolve in unison

with the crankshaft, so that the pick may be given from the same side of the loom any number of times in succession. This is effected by the application of a clutch

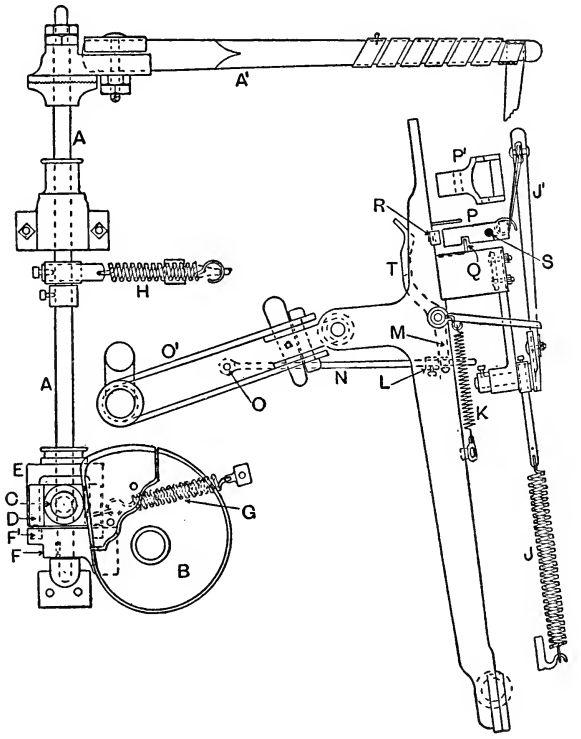


FIG. 31.

arrangement, by means of which the picking cone may be driven back by the tappet without imparting any movement to the picking stick. The construction of this mechanism is similar to that shown in Fig. 29. A

full description of the parts is unnecesssary, but attention is drawn to a few details in which this motion varies from that previously described. The loom is fitted with four boxes at each side, the box front being formed by turning up the box shelf as shown at Q. The picker P, also shown in plan at P^1, is of necessity placed in front of the box, and works on the spindle S. The box swells that operate the warp protector work through an aperture cut in the back of the shuttle-box, this latter being made of hard wood. The difference in the outline of the picking tappets of these two types should also be noted, as this will give some idea of the influence which the speed of the shaft and the tappet has upon the various factors that constitute a perfect tappet. The clutch by means of which the picking is controlled consists of three parts: (*a*) The bracket D to which the picking cone stud is secured. This bracket is free to turn on the upright shaft A, but cannot move in either direction vertically. (*b*) The winged bracket E, which works in the grooves of the bracket D, but is also capable of being moved vertically by means of the forked lever E^1, as shown in Fig. 32. (*c*) The dished boss F, which is securely keyed on to the bottom of the upright shaft, and is made with a recess at each side, with which the wings of bracket E engage.

The diagrams show the bracket E lifted and out of gear with the boss F; consequently, as the tappet B revolves and strikes the cone C, it is forced back without imparting any motion to the upright shaft A or the picking stick A^1. The brackets E and D, also the cone C, are drawn back into position by means of the spring G. The upright shaft is drawn back after picking by the spring H. Assuming that the bracket has been lowered so that the wings engage with the recesses in the boss F, the cone that is forced back by the tappet will cause the

upright shaft and picking arm to oscillate and so drive the shuttle out of the box.

The method of indicating the pick is shown in Fig. 32.*

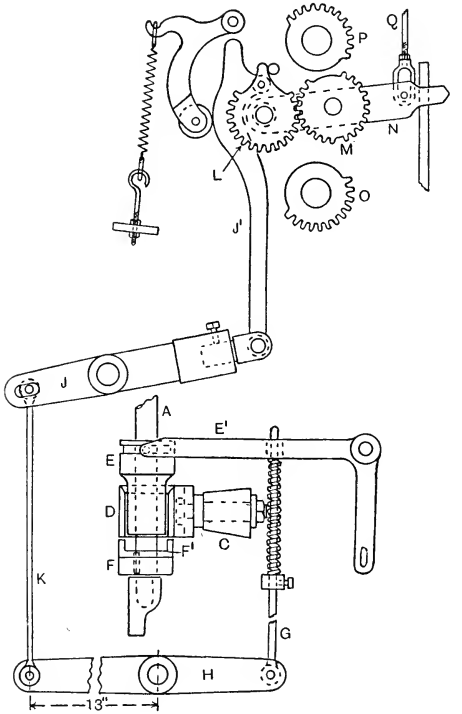


FIG. 32.

The principle adopted is exactly the same as that employed for controlling the movement of the boxes in this loom, to which subsequent reference will be made.

* The parts G to P inclusive are shown in side elevation. A to F are in end elevation.

The fork lever E^1 spanning the bracket E is operated by the rod G and the lever H. This latter in turn is actuated from the lever J, to which it is connected by the rod K. The lever J is attached by a connector J^1 to a vibrator wheel L, which is in gear with the vibrator M supported in the vibrator lever N. The vibrator M is operated by the upper and lower semi-toothed cylinders O and P respectively, into either of which it can be put in gear through the medium of the connecting rod Q, which receives indication according to the pegging of the box chain.

An objectionable feature of this type of picking motion is the amount of force that must be expended in order to destroy the energy contained in the various springs which constitute part of the mechanism. From experiments made, this force is in excess of that actually required for driving the shuttle from box to box. In this motion there are no fewer than five forces, in addition to the resistance of the shuttle, to be overcome when picking takes place—namely: The springs G, H and J (the latter being used for drawing the picker clear of the boxes); the pressure exerted on the shuttle when in the box, by reason of the swell spring and the stop-rod springs K; and the frictional resistance of the picker on the spindle. The tuner should ever be alert to these factors, which are present in every form of picking mechanism to a certain degree, and should adopt every possible means to reduce their opposing influences to the minimum.

SHUTTLE-EASING MOTIONS.—It is with the object of mitigating the above defect that shuttle-easing motions have been introduced into certain types of picking mechanism. Such a device is illustrated in Fig. 31. The mechanism is simple in construction, and may be applied to most looms fitted with a stop-rod as warp protector. The stop-rod finger T is made with a projection M, which

is provided with an opening to admit the rod N. This rod is supplied with an adjustable collar L, and is pivoted on the stud O fixed in the crank connecting arm O^1. Fig. 31 shows the position of the several parts just as the pick is about to take place. The crank-arm is at its lowest point and the stud O in the near position to the stop-rod finger. The collar L is set at such a distance from the stud O as to push the projection M forward, and the stop-rod finger T clear of the box swell. This relieves the shuttle of the pressure exerted by the two stop-rod springs K, as these are made fairly strong in order to keep the stop-rod steady when the shuttle enters the box, or when the loom knocks off. As the crank approaches the back centre the action of the collar against the projection is gradually withdrawn by reason of the rod being lifted into a position out of a straight line. This leaves the stop-rod finger free to assist in checking the shuttle as it enters the box.

Shuttle-checking Motion.—This motion has received considerable attention during recent years, and several improvements have been introduced. The primary cause necessitating such improvements is the gradual speeding-up of all types of power-looms, the increased efficiency of the loom being obtained in this direction, rather than by effecting any radical change in its construction. The increase in the speed of a loom is attended by a quicker movement of the shuttle, which requires more effective means for checking. This applies more particularly to box looms, where the checking is not alternate as in the plain single-box loom. The most effective form of a checking motion is found in looms where the picking takes place from each side alternately. This consists of a strap run along the front of the going part, extending from one box to the other. The strap is first secured, in buckle form, to leather tags, which fit on

the spindle behind the picker. The ends of the strap are fixed to the outer end of the shuttle-box by means of the spindle spring or by a set-screw. The check strap is left of such a length that when the shuttle enters either box, the strap will be drawn in the same direction, and so draws the picker forward at the opposite side ready to check the shuttle as it is returned. With this method the length of the check can be easily regulated, whilst the checking of the shuttle is not influenced by any variation of the pick. In looms where the checking is required to take place at the same side a number of times in succession, the above method is not applicable. On such looms it is necessary to have the checking at each side working independently of the other. This is accomplished by employing a short length of strap at each side, one end being fastened to the tag on the spindle, and the other end attached at some convenient point to the breast beam. The strap is so adjusted for length and position that when the going part recedes from the breast beam, the strap and the picker are drawn forward. As the going part approaches the breast beam they are then drawn backwards by means of the switch stick J^1 and the spring J, Fig. 31. The shuttle, which enters the box at this time, is gradually brought to a state of rest by contact with the receding picker, irrespective of the side from which picking has taken place. The objectionable feature to this form of checking motion is that the checking of the shuttle can be effectively done only when the going part is in a certain position. As a result the pick has to be regulated to suit the checking, and not, as is desirable, the checking to the picking.

Recent inventions have aimed at overcoming this difficulty, and at the same time obtaining a more effective form of checking motion, by employing an eccentric to control the checking strap. The eccentric is operated

from some convenient part of the loom, usually the main shaft, and possesses the advantage of allowing the checking motion being set to suit the picking and speed of the shuttle. This principle has been further developed by employing an eccentric for each side of the loom, by means of which the checking is placed under separate control.

Defective Checking.—This is responsible for the pickers, shuttles, and strappings wearing out too quickly. Defects in the piece are occasionally brought about by the shuttle rebounding as the weft falls slack in the shed, and during beating-up forms into small loops, varying in size to the extent of the slack weft. This defect may also be responsible for the weft stop-motion not working satisfactorily. A more serious defect due to imperfect checking is the stripping of the weft, which is an unnecessary waste of material and time. Faulty checking is also frequently the cause of unsatisfactory picking.

Under-pick Motion.—A picking motion of the under-pick type, which is employed on the well-known "Dobcross" loom, is illustrated in Fig. 33. The mechanism of this motion varies considerably from that of the motions previously described. The picking arm A is pivoted below the boxes on a stud B^1 in the bracket B. The arm extends upwards and works between the framework of the box C and the picker spindle D, and is directly behind the picker E, to which it is attached by means of a strap. The plan view shows the arrangement of the shuttle-box, picker and spindle. The action of the picking arm on the picker partakes of the nature of a push along the spindle. The picker projects through the aperture in the box framework, and makes contact with the shuttle as shown. A swell F forms the front of the box, which is built of steel and is fairly light but rigid. The picking arm is actuated from the picking shaft G,

which in this instance makes one revolution per pick. On this shaft are placed the picking tappets H, one at each side of the loom; these carry a picking bowl J, and are free to move along the shaft in a lateral direction only. The tappets are constructed with two projections which fit into the recesses of the picking block K, which, being secured to the picking shaft, impart a rotary motion to the picking tappet and the bowl. Below the picking shaft and at right angles to it are placed the square shafts L; these are supported in suitable bearings fixed to the cross rails, as shown in the side elevation. The square shafts are provided with a picking shoe M, directly underneath the block K, and also with a lever N, to which the picking arm is attached by means of the connector and the strap O. The lateral movement of the picking tappet is controlled by the forked lever P which spans the grooved collar on the tappet. The lever P receives motion from the rod P^1 and the pick jack P^2, which is actuated from the vibrator Q, to which it is coupled by means of a connector Q^1.

The pick may take place a number of times in succession from either side of the loom, according as the picking bowl is drawn over or away from the picking shoe. This is governed by a pulley or blank in the pattern chain, which puts the vibrator Q in gear with either of the semi-toothed cylinders R or R^1 respectively.

A modification of this picking motion has recently been introduced, the object of which has been to facilitate an increase in the speed of the loom. The motion has been converted into a whip pick, and the box motion has also been improved by making it positive in action whether the boxes are being lifted or depressed. These improvements have rendered an increase of 10 per cent. in speed an easy matter. The chief feature of this improvement consists in the substitution of a clamp bracket in place

of the lever N. This bracket holds the picking stick, which is now inside the loom frame. The picker being connected by means of a flexible strap to the top of the picking stick, the picking stick A is replaced by a switch stick employed solely for the purpose of drawing the picker back, to keep it clear of the boxes after picking has

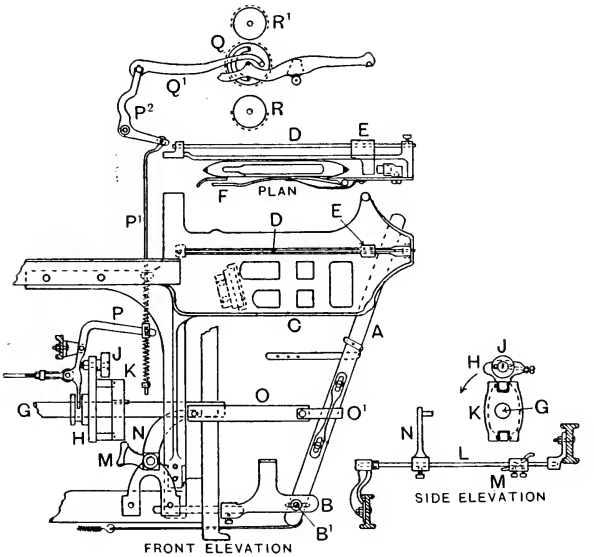


FIG. 33.

taken place. This alteration in the picking mechanism enables a smart blow and a quicker passage to be imparted to the shuttle, a feature of all whip pick motions, which is not attended by any appreciable vibration or increased wear in the mechanism.

TIMING OF THE PICK.—The correct timing of this type of picking motion, as of all motions, is of the utmost importance, for imperfect timing of the pick has an in-

jurious effect on the working of the loom. It is important to note that the crankshaft in this loom works up from the bottom centre towards the weaver. To time the pick, turn the loom to bring the crank to the top centre. When in this position the picking bowl should be impinging on the shoe, and gradually depressing it, drawing the connector strap tight until the picker is in contact with the shuttle tip, and ready for the accelerated movement being imparted. The shuttle will then enter the shed when the going part is about one inch from the back position. The connector strap O should always be kept as near as possible the same length, with the object of presenting the picking shoe to the bowl in the same relative position. If the connector strap is too long, the bowl cannot engage with the shoe at the same time and place, consequently the action of the pick becomes jerky, though not necessarily stronger, as is sometimes supposed. To allow of any alteration in the timing of the pick, the picking bowl stud is secured in the concentric slot of the tappet H. By this means the bowl may be put forward or backward according to requirements.

Setting the Pick.—The strength of the pick in this motion can be regulated by (*a*) altering the position of the connector strap O^1 on the picking stick, raising or lowering to decrease or increase the stroke of the stick; (*b*) an alteration in the position of the stud B^1 in the bracket B; (*c*) moving the picking shoe along the shaft to bring it more directly underneath the picking bowl (this will increase the pick), or moving it farther back to reduce the pick. Any alteration here will also affect the timing of the pick slightly.

Early and Late Picking.—All picking motions are constructed with the object of affording scope for timing the pick. This is essential since the timing of the pick is often influenced by the timing of the shedding motion,

and in some instances to a slight extent by the box motion. Early picking is practised in order to facilitate early shedding, for reasons already given on a previous page. Occasionally it is advantageous when weaving with tender weft or badly spun weft cops to time the picking a little earlier. This gives the shuttle more time to travel across the race, and the pick need not be as strong, so that a gentler action is applied to the weft as it is drawing off the cop. Late picking is sometimes adopted to allow the boxes a little more time to arrive at a state of rest before picking takes place. Usually late picking is resorted to in order to increase the force of the pick. This is bad practice, since late picking is always harsher the nearer the crank is to the back centre when the actual blow is delivered. This is attended by considerable friction, especially in the driving wheels, in which, if the teeth are not broken, they quickly wear out. When the teeth are worn down in this way there is always an amount of backlash when picking takes place, resulting in a jerky motion being transmitted to the going part. This defect has occasionally been remedied by having a new keyway cut in the wheel, or a new keybed cut in the shaft, in such a position as to bring an unworn portion of the wheels in gear when picking takes place.

Defects in Picking Motions.—A defect common to all picking motions is due to the mechanism becoming "picker-bound." This is brought about by reason of the picker being drawn in close contact with and bearing heavily against the buffer before the tip of the tappet nose has passed the cone in the "over-pick" type, or the picking bowl clear of the shoe in the "under-pick" type. When picking takes place, the picker should have sufficient play to move freely along the spindle. This can only be effected by carefully setting the picking stick in position, and by proper adjustment in the length of the

connecting strap. Whenever any alteration is deemed necessary the loom should be turned over by hand to ascertain the extent of the chase given to the picker. This defect is mainly responsible for the expense incurred in the renewal of pickers, strappings, and picking sticks. It is also a fruitful source of broken cone studs or strained studs. The latter lock the cone and prevent it from rotating, so that a flat is worn on the surface, which, when the cone is released, produces imperfect picking. The upright picking shafts and the low shaft pedestals in the over-pick type are frequently broken by reason of the above defect, whilst the square shafts are broken or twisted, and occasionally the picking tappets broken, in the under-pick type.

Tight and Slack Shuttle-boxes.—This is a defect which occasions a considerable amount of trouble in the working of the loom, and is always a harassing problem to the tuner. Such a defect is often accentuated by some slight discrepancy in the construction of the shuttle. Providing the shuttles are accurate in shape and all of the same size, then with the boxes set to the same gauge the shuttles are interchangeable and fit each box correctly. Occasionally the boxes are tightened to assist in checking the shuttle. This is to be discountenanced, as the picking motion has to overcome this increased friction when driving the shuttle out of or into a tight box. Too tight a shuttle-box may be the cause of the shuttle flying out; whilst, if the box is too slack, the shuttle will rebound and cause the loom to knock off, or the shuttle may be trapped in the shed. Tight shuttles are very frequently the cause of the boxes not working satisfactorily. If, when the boxes are being lifted or depressed, the tip of the shuttle comes in contact with the picker or the regulating bowls, and the shuttle is held unduly tight in the box, it is unable to slide forward clear of the obstruction, and so prevents the

boxes from working. A shuttle which fits slackly in the box, and not being required to run frequently in the wefting plan, may gradually work forward to the front of the box by reason of the vibration; when this particular shuttle is required in the order of the wefting, the loom will probably knock off.

WASTE OF WEFT.—Stripped weft and damaged weft cops are a direct loss to the manufacturer, and a vigilant eye should be kept on the weavers' waste to ascertain the proportion which may be traced directly to this source. Apart from the building of the weft cops during their preparation for the weaver, there are causes in the loom to which this defect may be due—*e.g.*, too strong a pick, imperfect checking, and tight shuttle-boxes. This defect is no doubt encountered in its worst form when weaving woollens of a medium or low quality. The weft is usually spun on to a bobbin, and in some instances in cop form on to a bare spindle. The strength of the yarn does not always allow of the weft cops being made hard and firm enough to withstand the usage to which they are exposed during weaving; consequently the weft is easily stripped or damaged beyond the possibility of its being woven. That stripping of the weft invariably takes place at one side of the loom is a feature to be noticed—*i.e.*, when the shuttle is travelling in the direction in which the nose of the weft cop is pointing. If the shuttle is brought to an abrupt stop by reason of any of the above-mentioned causes, the tendency can only be for the weft to slip off the bobbin, or in the case of weft cops they are liable to buckle and break by the impact. When the shuttle is moving in the opposite direction, the weft is forced tighter on to the bobbin, and only in rare cases are the weft cops damaged. Weft stripping has been brought about by a renewal of one of the pickers, which was renewed at the side of the loom referred to. The new picker

being harder and firmer than the old one, increased the force of the impact and caused the weft to strip. This can be usually remedied in looms where the pickers are interchangeable, by putting the new picker on at the opposite side, and using the partly worn picker in lieu of a new one. By this means a counteracting action is imparted to the weft on the bobbin as it enters opposite boxes.

PICKERS AND PICKING STRAPS.—Considerable reduction in the expenses caused by renewals in the picking motion may be effected by attention to minor details. The picking straps should be well conditioned before being used. The groove made in the picking stick to accommodate the strap should be quite smooth, and the picker where the strap is attached to it should be free from the sharp edges occasionally left on during its construction. Pickers should be thoroughly seasoned before using, and on no account should they be put into use if they possess the appearance of being in a state approaching absolute dryness; when pickers are used in this condition they are liable to break rather than wear. The condition of a picker can be fairly determined by the handle and its weight; a light picker is usually a very dry one. Pickers may be conditioned by immersing them in oil for a period of from six to eight weeks. They are then lifted out and allowed to drain for the same period in a temperate atmosphere. The durability of a picker is increased by the free use of buffer bits; these are placed on the spindle to serve as a cushion for the picker. The buffer should be connected to a strap in order to give a certain amount of resilience, and it should not be allowed to be driven into a solid mass against the spindle stud. Large numbers of pickers are supplied to the tuner with the socket smaller than is actually required by the diameter of the spindle. The sockets are sometimes enlarged by burning them out with a red-hot spindle

of the requisite dimensions. Occasionally an ordinary brace and taper bit is employed for this purpose; but this is a very unsatisfactory method, especially if the taper of the bit is very acute. The bit must be forced far enough to clear the inside of the socket; the outside will then be too large for the spindle. This reduces the wearing surface, as the socket in the picker soon becomes too large for the spindle, with the result that the passage of the shuttle is affected, and the picker requires more frequent renewal.

CHAPTER VI

SHUTTLE-BOX MECHANISM

Box Motions.—The box motion is an accessory to those power-looms adapted for the purpose of weaving cloths in which more than one colour or quality of weft is used, such looms having a greater scope for figuring in the weft. There is therefore some analogy between the capacity for figuring in the weft in the various types of box motions and the capacity for figuring in the warp in the various types of shedding motions. Plain looms are sometimes provided with two boxes at one side and a single box at the other—such a loom is usually referred to as a "Bastard" loom. Plain looms may be provided with two boxes at each side, but obviously the wefting capacity of such looms is very limited, since complicated wefting plans cannot be woven. These looms are mainly employed for weaving plain goods in which more than one shuttle is used merely to mix the weft. The shuttles are picked two-and-two, or in the loom provided with two boxes at each side, three shuttles could be employed and the weft run in three odd picks. The advantage accruing from this arrangement is that a better distribution of the weft takes place, which reduces shadiness in the piece due to faulty or uneven yarn. In looms for weaving fancy goods a more comprehensive box motion is necessary. On such looms there are two classes of box motions adopted—namely, the circular box motion and the rising or drop box motion. The main

feature of difference between the two classes is found in the method of carrying the shuttles. In the circular box motion the shuttles are accommodated in a series of cells arranged in circular form around a common axis on which they revolve. In the other class the boxes are arranged in shelf form one above the other. This class of box motion may be either of the rising or drop box type, according to the mechanism employed for controlling the boxes. Such motions are usually constructed with four boxes at each side, which are capable of being operated so as to yield practically every order of wefting; the picking motion being constructed on the "pick-at-will" principle. The following factors should be in evidence in a good box motion: Each set of boxes must work independently of the other; any box at either side should be readily brought into operation, irrespective of its former position; the boxes should be easily adjusted for height with respect to the race; the box and pattern chains should be worked from the same cylinder; and the motion should be positive, but provided with an efficient escape or safety motion.

Most box motions of this latter class are worked on the lever principle; the levers being compounded in such proportions with respect to their fulcra and relative leverage as to impart the requisite movement to the various boxes.

A type of rising box motion is illustrated in Fig. 34. The boxes A form a rectangular block, and are provided with a tongue at each side which works in the two slides B and C of the framework. The boxes rest on the fork D, through which the box rod E passes, this being secured to the lug underneath the bottom box shelf. The rod E passes downward through the spiral spring F and the tube G, and is held in position by means of the lock-nuts H. Each set of boxes is controlled by two levers J and K to which they are connected by means of the chain L.

The chain is attached to the lever J at the point J^1, and is

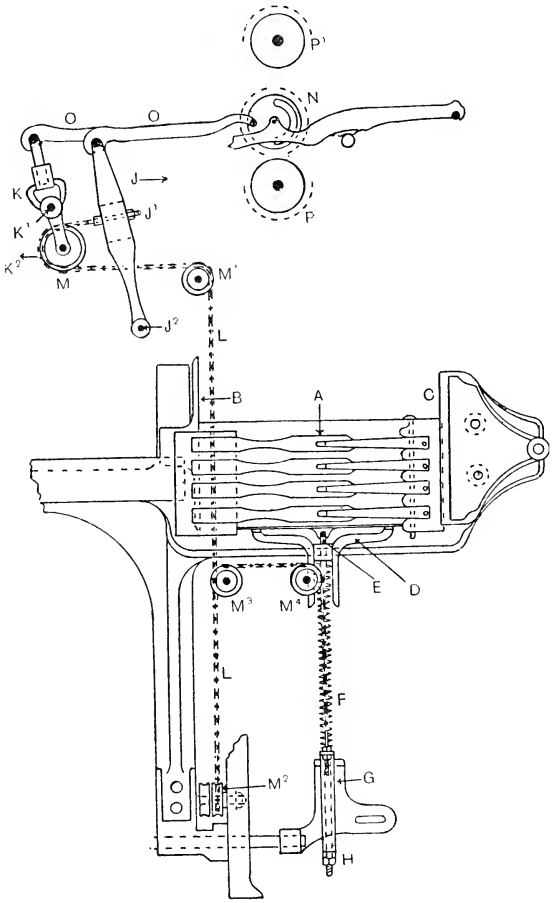


FIG. 34.

then carried forward over the pulley M fixed in the lever K, around the pulleys M^1, M^2, M^3, M^4, and is then finally

secured to the projection on the tube G. The levers J and K are actuated by means of the vibrators N, to which they are attached by the connectors O, the vibrators being operated by means of the semi-toothed cylinders P and P^1. These cylinders are quite separate from the cylinders that control the healds in order to allow of different timing of the healds and the boxes. The nature of the movement imparted to the boxes is harmonic, which is an essential in all types of box mechanism. The motion is of a negative character—*i.e.*, the boxes are drawn up in a positive manner, but they fall owing to their weight. This type of motion has been recently improved by making the movement positive in both directions—*i.e.*, whether the boxes are rising or falling. The spring F inserted over the box rod acts as an escape motion; in the event of the boxes becoming locked and unable to rise through any cause, the spring collapses and prevents breakages.

The action of the levers on the boxes is as follows: When the lever J is drawn back in the direction of the arrow, the leverage from the point J^2 to J^1 is such as to draw up the second box of the set level with the shuttle race. With lever J in its former position, and the lever K, which is pivoted at K^1, drawn back, the pulley M is thrown forward in the direction of the arrow K^2. To allow of this movement the chain must give out to the extent of the traverse of the pulley M, but as the chain is fixed to the lever J the length of chain drawn up is equal to twice the traverse of the pulley M. This would lift the third box of the set level with the race. To lift the fourth box the lever J would be drawn back with the lever K in its new position, or if it is required to lift it from the first box to the fourth at one operation, both the levers J and K would be drawn back simultaneously.

Fig. 35 illustrates another type of rising-box motion.

The motion is obtained from the geared vibrators A and B, which in turn are operated from the semi-toothed cylinders C and D. The vibrators B are connected as shown by connectors E to the end of one of a series of five levers. The first and second of these levers control the boxes on the left-hand side of the loom, the third and fourth control the boxes on the right-hand side, and the fifth lever controls the picking mechanism. The first and second connectors are attached to the levers F and G respectively; the lever F has its fulcrum on a stud F^1, and the lever G has its fulcrum on a stud G^1, which is fixed at the end of the lever F.

The motion from these levers is conveyed to the lever J through the connecting rod H, on which is placed a spiral spring. This, together with the spring on the box rod L, forms an efficient escape motion, as the motion in this type is positive in both directions. The boxes are supported on the upright rod L, which is attached by means of a short swivel lever K to the end of the lever J.

To raise the second box level with the race the lever G is depressed, the proportionate leverage on each side of the fulcrum G^1 being such as to yield the exact lift to the boxes. To raise the third box to the level of the race the lever F is depressed; the proportionate leverage on each side of F^1 is such as to give double the lift of the lever G. To lift the fourth box to the level of the race both levers are brought into action at the same time. The levers F and G are shown in plan at M.

Fig. 36 illustrates a type of box motion constructed on the swing lever principle. This type of box mechanism possesses an advantage by reason of the boxes at each side of the loom being in direct contact with the prime mover. The mechanism consists of a clutch barrel A, in connection with which are the toothed segments B and C. These latter are placed one on each side of the barrel, and

are free to move laterally so that they can be put in contact with the barrel with which they form a clutch, or drawn out of contact with it.

The movement of the segments B and C is controlled from the dobby in such a way that they are readily placed to gear with the star wheels D and E. These star wheels are constructed with half the number of their teeth in different planes on the circumference, as shown by the shaded portions. The relative numbers of teeth in the segments B and C, and in each section of the star wheels, are such as to turn the star wheels half a revolution. The segment B actuates the star wheel D, and the segment C the star wheel E. In the star wheels adjustable studs D^1 and E^1 are fixed on which the connecting rods F and G are pivoted. The other end of these rods form the fulcra of the swing lever H at the points J and K, the boxes being supported on the box rod L, pivoted on the swing lever H at the point L^1.

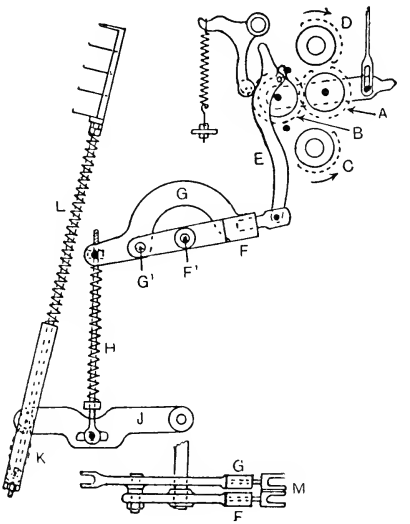


FIG. 35.

To raise the second box the segment C is moved to engage with the star wheel E. This latter being turned half a revolution brings the stud E^1 to the upper position.

The traverse of the stud in combination with the leverage of H, which now has its fulcrum at point K, is such as to lift the second box to the level of the race. To raise the third box, the star wheel E being in its former position, the segment B is moved to engage with the star wheel D. The stud D^1 in this wheel has a greater traverse than the stud E^1, and this in combination with the lever H, which now has its fulcrum at point J, lifts up the third box to the level of the race. To raise the fourth box to the level of the race a combination of the above motions is performed simultaneously.

Setting the Boxes.—It is of the utmost importance that the boxes rise level with the shuttle race, and provision is made for adjusting their traverse at various points in the mechanism. The setting of the boxes is often a harassing duty of the tuner. This is due to the levers in the various box motions being compounded in such a way that any alteration at one or other of the various points has an effect on other boxes of the set besides the one it is desired to regulate. Owing to this feature the setting of the boxes cannot be determined by "rule of thumb." Any alteration necessary should be carried out carefully, noting the influence that any alteration at a given point will have upon the whole set of boxes on that particular side. To deviate from this method of setting only results in alterations first at one point and then at another, until by mere chance the correct position is obtained.

A common cause of the boxes being out of truth is due to their irregular use. Frequently the loom is run for long periods with only the first and second boxes at one or both sides in use. Thus the surface of the studs, pulleys and chains wears down at particular points, and, as a result, when the other boxes are brought into operation

they are often out of truth, and the whole set of boxes requires re-setting.

CHAIN-MAKING FOR BOX MOTIONS.—The method of arranging the shuttles and the building up of the box chain to produce the required wefting plan is a factor

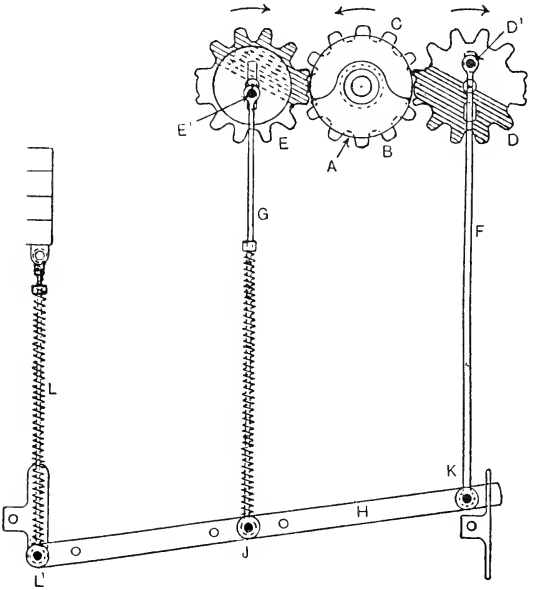


FIG. 36.

which may largely affect the satisfactory working of the box motion. It is possible to build up the box chain in such a manner as to tax the box motion and the loom to their utmost capacity; and, in addition, to impose undue strain on the weaver by reason of the increased alertness and activity necessary to follow the shuttles through their respective changes. By carefully planning

out the box chain, the above result can, however, be frequently avoided, and the desired movement to the various boxes obtained with the expenditure of a minimum of power.

Features in Chain-making.—The following features should be observed when building up a box chain: (*a*) Each shuttle in the wefting plan should be brought into sight as often as possible—by preference into the top box on that side of the loom on which the weaver stands to change the shuttles. (*b*) Those shuttles which run most in the wefting plan, or those in which the cops run off most frequently—*e.g.*, as in a backed or double cloth made with thick woollen weft for the backing yarn—should be planned to run into sight in order to enable the weaver to catch the weft before it is fully spent. (*c*) Each shuttle should be kept to its own box as far as is practicable, since this renders it easier for the weaver to follow the order of running, and is of assistance when placing the shuttles in their respective order after lagging back for broken weft or other defects in the piece. Attention to this feature is specially essential when the wefting plan contains two or more colours or qualities of weft which are very similar in character. (*d*) Double and treble moves should be avoided as much as possible; in a negative box motion a double or treble lift is preferable to a double or treble drop. (*e*) When a double or treble move takes place it is best to have the shuttle picking into the box on that side, since this allows more time for the boxes to attain a state of rest ready to receive the incoming shuttle. (*f*) The boxes should be balanced—*i.e.*, when the boxes on each side of the loom are changing at the same time, they should be balanced by one set being lifted and the other set lowered; less power is absorbed by this method. (*g*) The complete working of the shuttles should be arranged with a view to maintaining uniform tension on the lists

of the piece whilst the wefts are running off at different times. This may often be impracticable, so far as the arrangement of the box chain is concerned, but it may be largely regulated by the weaver effecting an occasional change of the shuttles—*i.e.*, replacing a half-spent weft cop by a full one. (*h*) The complete repeat of the wefting plan should be worked out by giving as few movements as possible to the boxes, consistent with the foregoing rules.

Building up Box Chains.—A very common method by which the experienced chain-maker determines the order of working the boxes is by first passing over, from one side to the other, into imaginary boxes, different sizes or forms of tokens, usually metal discs, numbered to represent the various shuttles to be employed. Having obtained a complete repeat of the wefting plan in this manner, the box chain is built up, and at the same time the tokens are passed over from side to side as a check on the work. This is no doubt as expeditious a method as it is possible to adopt for the experienced operative, but an objection is found in the fact that no record of the running of the shuttles, or of a box-chain plan, is kept for future reference. This is very desirable when the wefting plan is complicated, as frequently the chain cannot be kept intact after use, but its components are again used in the construction of a box chain for some other wefting plan. After a time the original box chain may be again required, as is occasioned by a repeat order for that particular cloth. The former order of procedure in building up the box chain is again necessary, and this operation in case of a complex wefting plan may take up more time planning the order of running the shuttles than is taken to build up the actual chain. A further advantage of keeping a box-chain plan of the running of any particular wefting plan is that the plan could be given to an inexperienced operative, who could build the box chain

from it in a similar manner to pegging the lags for the healds from the point-paper plan of the design.

The following "paper" method of illustrating box-

Left.		Right.		Picking.	
4th		4th			
2nd	3rd	3rd	2nd		
5	4	3	2	1	
					Pick from right-hand side.
				o	„ „ left-hand „
			o		Second box right and top box left.
o					„ „ left „ „ „ right.
		o			Third „ right „ „ „ left.
	o				„ „ left „ „ „ right.
		o	o		Fourth „ right „ „ „ left.
o	o				„ „ left „ „ „ right.
o			o		Second „ right „ second „ left.
	o		o		„ „ „ „ third „ „
o		o			„ „ left „ „ „ right.
o	o		o		„ „ right „ fourth „ left.
o		o	o		„ „ left „ „ „ right.
	o	o			Third „ right „ third „ left.
o	o	o			„ „ „ „ fourth „ „
	o	o	o		„ „ left „ „ „ right.
o	o	o	o		Fourth „ right „ „ „ left.

FIG. 37.

chain plans is one which can be recommended. The manner of building up the box chain to bring any box level with the race, and to pick from either side, is shown in Fig. 37. This illustration shows the arrangement of

the levers for the box motion shown in Fig. 34, but it will also serve as an illustration for most modern box motions, the only necessary alteration being in the position of the levers employed for controlling the respective boxes.

On the box-chain pin there are spaces for five tubes or pulleys, the effect of placing pulleys in any of these spaces being shown in Fig. 37, as follows: The spaces are numbered 1 to 5. With No. 1 space left blank the pick would take place from the right-hand side of the loom; a pulley placed in this space causes the loom to pick from the left-hand side. A pulley placed in the space No. 2 indicates for the second box on the right; a pulley in the space No. 3 indicates for the third box on the right; whilst pulleys placed in both the spaces Nos. 2 and 3 indicate for the fourth box on the right. Similarly for the boxes on the other side of the loom, a pulley in the space No. 5 indicates for the second box on the left; a pulley in the space No. 4 indicates for the third box on the left; and pulleys placed in both the spaces Nos. 4 and 5 indicate for the fourth box on the left. This principle of chain-making is further illustrated by the boxing plan in Fig. 38, made out for the wefting plan given. This only requires two shuttles and two boxes on each side; the boxes are numbered 1, 2, 3, 4 on the left-hand, and 4, 3, 2, 1 on the right-hand sides respectively. The shuttles at the commencement are shown placed in boxes Nos. 1 and 2 on the left-hand side. The order of running is indicated by means of the crosses and letters—*the crosses* denote the shuttle leaving the box on that side, the *letters* indicating the box to which it is sent on the opposite side.

The shuttle A is indicated as being sent from No. 1 box on the left to No. 1 box on the right, then back again to No. 1 box on the left, giving two successive picks from the shuttle A. The second box on each side is next lifted,

and the shuttle B is indicated as being sent from No. 2 box on the left to No. 2 box on the right. The shuttles are sent from side to side in this manner until they have completed one repeat of the wefting plan.

The position of the shuttles at this stage leads to a consideration of an important factor in chain-making. It will be seen that the shuttles after completing one repeat of the wefting plan are on the opposite side from which they commenced. To make up the box chain for this repeat only, would not give a succession of repeats of the wefting plan. For instance, the first lag of the box chain would be made up to pick the shuttle A from the left-hand side of the loom, the same lag coming round on the lag cylinder to indicate again for the first pick of the wefting plan. But, as already pointed out, the shuttle A is now on the right-hand side of the loom, consequently the next lag of the box chain—viz., the seventh—must be built up to pick from the right-hand side; and similarly for the shuttle B; and the shuttles run for another repeat of the wefting plan in order to bring them back to their original position. This necessitates the box chain being made on 12 lags, or twice the number of picks in the wefting plan.

This obtains for all wefting plans in which an odd number of picks is required from any one colour or quality of the wefts composing the repeat. For instance, a simple wefting plan is as follows:

$$\left.\begin{matrix}\text{49 picks black . . .}\\ \text{1 pick fancy twist . .}\end{matrix}\right\} = 50$$

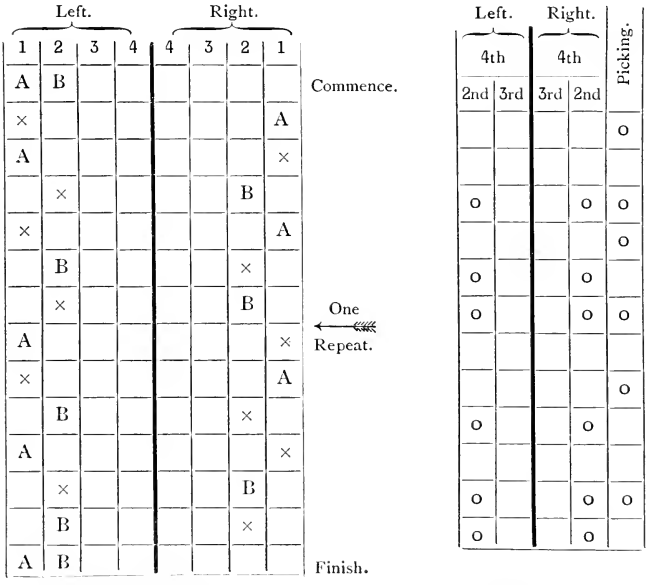
This wefting plan is complete on 50 picks, but the box chain will repeat at 100 on account of the odd pick of fancy twist.

This feature in chain-making is responsible for the use of excessively long box chains. To obviate this objectionable feature, the picking mechanism of some looms

has been so designed as to cause the pick to take place from that side of the loom on which the shuttle is brought level with the race, the indication being given from the

WEFTING PLAN

$$\begin{matrix} A — 2\ 1 \\ B — 1\ 2 \end{matrix} = 6.$$



BOXING PLAN. BOX-CHAIN PLAN.

FIG. 38.

shuttle-box swell and not from the box chain. Such an arrangement not only simplifies the making of the chain, but also saves considerable time in building up the box chain, as no account of the picking is necessary, and the box chain only requires to be made up for one repeat of

the wefting plan irrespective of any odd picks it may contain.

Upon further consideration of the order in which the shuttles are run in the boxing plan in Fig. 38, it will be seen that the shuttle B does not come into sight, and also that the boxes are not balanced. Each time the shuttle

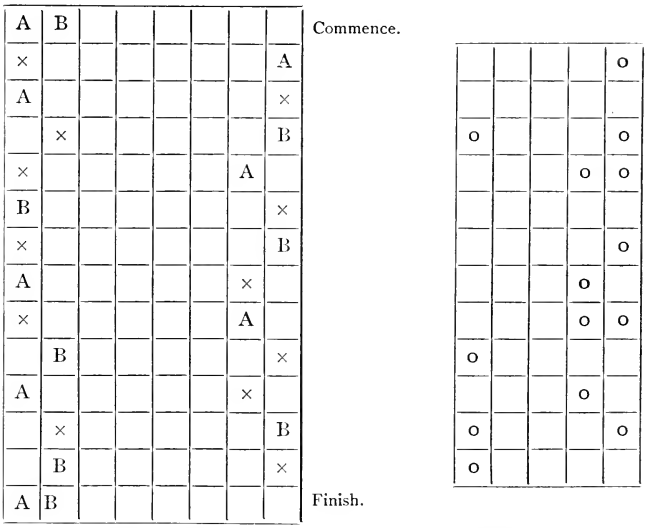


Fig. 39.

B is required, the second box on each side of the loom has to be lifted, and again dropped to bring the shuttle A into operation.

The method of running the shuttles for this wefting plan, in accordance with the principles advocated, is shown in the boxing plan given in Fig. 39, and it possesses the following advantages: (1) Each shuttle is shown running into the top box on the weaver's side, shuttle A

once and shuttle B three times in one complete repeat. (2) The boxes are balanced when a movement at each side takes place. (3) The number of the movements to be given to the boxes is reduced to the minimum. The method of obtaining the box-chain plan from the boxing

WEFTING PLAN.

A — 2 2
B — 2 =8
C — 2

Left. Right.

1	2	3	4	4	3	2	1	
A	B	C						Commence.
×							A	
A							×	
	×						B	
	B						×	
×							A	
A							×	
		×					C	
		C					×	
A	B	C						Finish.

Boxing Plan.

Left.		Right.		Picking.
4th		4th		
2nd	3rd	3rd	2nd	
				o
o				o
o				
				o
	o			o
	o			

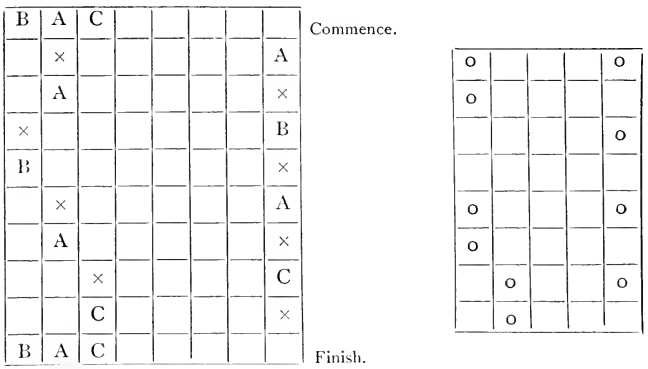
Box-chain Plan.

Fig. 40.

plan, which only shows the order of running the shuttles, is as follows: Circles to represent pulleys are placed in the picking column, on the corresponding horizontal row of the box-chain plan, for each cross that appears on the left-hand side of the boxing plan. A pulley denotes a pick from the left-hand side, and a blank a pick from the right-hand side, as already stated. Next dealing with the boxes, circles are shown placed in the columns of the

box-chain plan, which indicate the boxes that are employed in the boxing plan, a circle being substituted for *either* a letter or a cross appearing in these columns.

No. 1 boxes on each side are not taken into account, as these are level with the shuttle race, with the box chain all blanks. As the second box on each side is only used for this wefting plan, no circles appear in either of the columns Nos. 3 and 4 of the box-chain plan.



Boxing Plan. Box-chain Plan.

Fig. 41.

The method of placing the shuttles at the beginning of a boxing plan will determine the order in which they can be run. For instance, the wefting plan shown at Fig. 40 would be best run by using three boxes at one side and one box on the other side, by preference on the weaver's side. If the shuttles are placed as shown in Fig. 40, a double lift takes place when the shuttle C follows A, then a double drop as the shuttle A follows C. This can be easily avoided by placing the shuttles as shown in Fig. 41. Here a single drop takes place as the shuttle B follows A,

and a single lift as the shuttle C follows A, so that single moves only take place whichever shuttle is required, the box-chain plan for each order being as shown.

WEFTING PLAN.

A — 1 1
B — 1 =6
C — 3

Two shuttles on A weft

Left.				Right.				
1	2	3	4	4	3	2	1	
	B	C	*a*			A		Commence.
A						×		
	×					B		
			×		*a*			
		×					C	
		C					×	
		×					C	
			a		×			
	B					×		
×						A		
		C					×	
		×					C	
		C					×	
	B	C	*a*			A		Finish.

BOXING PLAN.

Left.		Right.		Picking.
4th		4th		
2nd	3rd	3rd	2nd	
			o	
o			o	o
o	o	o		o
	o			o
	o			
	o			o
o	o	o		
o			o	
			o	o
	o			
	o			o
	o			

BOX-CHAIN PLAN.

FIG. 42.

The rules given for building up box chains are further illustrated by means of the wefting plan in Fig. 42. The chain is shown completed on the least possible number of lags. The shuttles, with the exception of B, are kept to their own boxes; and on the eighth lag, where a double

drop takes place—*i.e.*, from the fourth to the second box on the left—the shuttle is picking inwards.

The defects of this chain are: (1) The boxes are not balanced, as lifts and drops take place on each side simultaneously. (2) The shuttle (*a*) is run "blind," this term being applied to those shuttles which do not show in either the top or second box on the weaver's side of the loom. Fig. 43 shows an alternative method of running the shuttles for this wefting plan; and although the chain occupies double the number of links as in Fig. 42, it possesses advantages over the former chain in that (1) the boxes are much better balanced; (2) the shuttles run into sight of the weaver more; and (3) only three boxes on each side of the loom are employed.

The above examples illustrating the principles of building up box chains are taken from simple orders of wefting; but they cannot be taken as representing the general run of wefting plans, nor do they indicate the intricacies encountered in the operation. It is only when box chains have to be made for wefting plans which necessitate five or more shuttles that the real difficulties are apparent.

Frequently the tuner and the weaver have to adopt some plan in order to deal with the difficulties which arise in running the shuttles. For example, a wefting plan may be such that four boxes are not sufficient to allow of the necessary changes being made by the box motion. By the weaver effecting, however, a change of the shuttles (by preference those which carry the wefts for the overchecking, which is known as "planting" the shuttles), the running of the wefting plan is made possible. This is more frequently the case when weaving large check patterns, in which alternate overcheckings are of different colours. It is possible, when the checking shuttles are run into the bottom box at either side, to make an attachment to the starting lever, in order to throw off the loom

Left.				Right.				
1	2	3	4	4	3	2	1	
a	A					B	C	
	×				A			Commence.
	B					×		
×						*a*		
C							×	
×							C	
C							×	
		a				×		
	×					B		
	A				×			
×					C			
C					×			
×					C			
	×						A	
	B					×		
		×				*a*		
		C			×			
		×			C			
		C			×			
a						×		
	×					B		
	A						×	
		×					C	
		C					×	
		×					C	
a	A					B	C	Finish.

BOXING PLAN.

Left.		Right.		Picking.
4th		4th		
2nd	3rd	3rd	2nd	
o		o		o
o			o	
			o	o
				o
	o		o	
o			o	o
o		o		
		o		o
		o		
		o		o
o				o
o			o	
	o		o	o
	o	o		
	o	o		o
	o	o		
			o	
o			o	o
o				
	o			o
	o			
	o			o

BOX-CHAIN PLAN.

FIG. 43.

when that box is lifted. This relieves the weaver from tracing the shuttles to that particular point in the plan in order to effect the change of shuttles by hand. Another method by which large checking plans have been run is to return one or other of the checking shuttles back again over the top of the warp. This necessitates the number of pattern lags for the healds being increased to, say, half the number of links contained in the box chain; lengths of pattern lags made up for the simple and standard weaves being kept in stock for this purpose. A blank pattern lag would be inserted to drop all the healds on the corresponding pick in the box chain which returns the shuttle.

When the pattern lags are increased to only half the number of the box lags, one of the other shuttles must be sent over the top of the warp when the blank lag in the heald pattern comes round. Under certain conditions this would be an advantage, and tend further to facilitate the building up of the box chain to prevent any changing of the shuttles by hand. Pattern lengths and pieces have been woven in this manner, but such plans are the exception to the general run of the fabrics woven on looms built with four boxes.

Complicated Weft Plans.—These are of two kinds: (*a*) Those in which 1 or 2 colours, in addition to the ground shades, are employed; but owing to the desirability of using two or more shuttles on the ground shades, for the purpose of mixing the weft, building up of the box chain is rendered more difficult. An example of this is shown in the following progressive wefting plans obtained from a simple check made up of 6 black, 6 white: (1) It is usual to employ two shuttles for the black weft. (2) Occasionally two shuttles are run on both the black and the white, the order of wefting being 1-and-1, from the respective shuttles. (3) The colouring of the

fabric may be altered by the addition of a single coloured thread as an overcheck. (4) Or by the addition of two single coloured threads as overchecks. (5) Converting the single cloth into a weft backed or double cloth, with a different colour or quality of yarn on the back. The final wefting plan, unless specially modified, would in such cases exceed the range of a four-box loom.

Such wefting plans are, however, more easily dealt with than those in which each shuttle carries a different weft, and which must be taken in a given order. The reason for this is that shuttles carrying similar wefts need not be run so as to take an equal number of picks off each, in one repeat of the wefting plan; but either of them taken as is the most convenient to facilitate the running of the checking and the backing shuttles as they are required in the plan.

(*b*) Wefting plans in which several colours or wefts are employed, the following being an example showing the developments:—

3 threads of shade I.
3 ,, ,, II.
3 ,, ,, I.
3 ,, ,, III.
} =12, colouring for the ground.

To such a checking pattern a single or double overcheck may have been added, or, as is frequently the practice, a backing weft, and occasionally a wadding weft, as in heavy overcoatings and motor cloths. When dealing with this type of wefting plan the limitation of a four-box loom is soon exceeded, by reason of the ground shades all running in odd picks. For such goods as the above, check backs and fancy tweeds, looms provided with six boxes at each side are employed.

Circular Box Motion.—This class of box motion is invariably adopted on quick-running looms of light and medium build, and is employed in the production of fancy

fabrics, such as check dress goods, tartan patterns, check linings, cotton handkerchiefs, and small woollen shawls. These fabrics are made from yarn of fine and medium counts to produce cloths up to a medium weight. Looms provided with a circular box motion are not constructed to employ a large shuttle, on account of the high speed and the shuttle-box space available; consequently they are unsuitable for weaving thick weft yarns, as changes would be too frequent; nor for weaving heavy cloths, as such looms being fitted with a " loose reed " as the warp protector motion are not adapted to this class of fabric.

Large numbers of these looms are fitted with boxes at one side of the loom only, usually six boxes in the set, and a single box at the other side. Such an arrangement reduces the weft figuring capacity of the loom by reason of the shuttle having to run in an even number of picks; nor would any advantage accrue if a set of boxes were placed at each side, unless the loom was constructed on the pick-at-will principle. The mechanism for operating the boxes is of two different types: (*a*) The mechanism may be such that the boxes can only be turned one box forward or one box backward at any given move. This restricts the capacity of the motion, as only those wefting plans which run in symmetrical order can be woven—*i.e.*, the shuttle containing the weft next required must always be in the box, forward or backward, adjoining the running shuttle. (*b*) Skip-box mechanism, which is so constructed that any box of the set can be brought level with the shuttle race, irrespective of its position to the box last used. The construction of the former type of motion is illustrated in Fig. 44. The boxes A are arranged in circular form, and are supported at the outer end on a spindle B, and at the front by means of a circular iron band. Fixed to the spindle is a pegged disc B^1, the pegs being equal distances apart, one peg for each of the six

boxes. Working in connection with the disc are two draw-hooks C and C^1, one in front and one behind the boxes, these being kept in easy contact with the disc pegs by means of suitable flat springs. The hooks are attached at their lower end to the levers D and D^1 respectively, which have their fulcrum on the stud D^2, and extend to the back of the loom. To the outer end of these levers the upright catches E and E^1 are pivoted, which project upwards through the apertures in the grid formed in the end of the lever F. This lever extends towards the front of the loom, where in turn it is pivoted to the escapement rod at F^2.

The method of operating the boxes is as follows: The lever F is made to rise and fall by means of the eccentric G, which is secured to the low shaft G^1 of the loom. The eccentric works in connection with the pulley F^1 pivoted in the lever F. The low shaft running at half the speed of the crankshaft will lift the lever on alternate picks only: this factor only allows of movement being imparted to the boxes on alternate picks, which, as already explained, limits the wefting capacity to an even number of picks from any one shuttle. To transfer motion to the boxes one or other of the upright catches E and E^1 is pushed forward to engage with the lever F; the apertures in the grid are sufficiently large for the catches to stand clear of the lever and allow it to rise without engaging with them, as occasion requires. In Fig. 44 the upright catch E^1 is shown over the grid and lifted up to its highest position. The result of this is to tilt the lever D^1 and at the same time depress the draw-hook C^1, which, engaging with a peg in the disc, turns the boxes one space backward. To obtain a forward movement of the boxes the catch E would be placed over the grid in the lever F in order to depress the draw-hook C, which, being in front of the boxes, engages the disc peg and turns them forward.

INDICATING TO THE BOXES.—The mechanism employed for selecting one or other of the upright hooks to be lifted is operated as follows: Steel pattern cards as shown at H and H^2 are employed: the card H can be used in two ways, to indicate for either a backward move, as shown at H^1, or a forward move as at H. The cards are connected together by links and passed over the card cylinder J. The outer holes in the card fit on notches cast on the cylinder to keep them in position. The hole nearer the centre of the card gives the indication to the boxes. Working above the cylinder J are two tumbler levers K and K^1, in each of which is fixed a small stud K^2; one or other of these will enter the hole in the pattern card when such a card is brought on to the upper surface of the cylinder. If the hole is on the left-hand side it indicates to the tumbler K^1, and a backward movement is imparted to the boxes, as shown in Fig. 44. The card placed with the hole to the right-hand side indicates to the tumbler K, and a forward movement of the boxes results. A blank pattern card as at H^2 denotes no movement of the boxes.

The tumblers are provided with feelers L and L^1, which work in connection with the tables on the upper end of the bell-crank levers M and M^1, these being finely balanced on their fulcrum with a slight bias on their lower arm. This is to prevent them from working forward too easily and pushing the upright catches on to the lever F, unless indicated from the pattern chain. The small springs X are also introduced for the same purpose of keeping the upright catches clear of the lever. Whenever either of the pins in the tumblers enters a hole in the pattern cards it allows the tumbler to drop slightly lower than is otherwise possible, which, by reason of its weight and the feeler resting on the table of the bell-crank lever, is sufficient to push the corresponding catch forward on to

the lever; this latter when lifted would depress one of the draw-hooks and turn the boxes.

The card cylinder is operated by means of the eccentric N on the low shaft, which works in combination with the vertical lever N^1. At the top of this lever the open grid O is secured, the bars of which pass between the tumblers

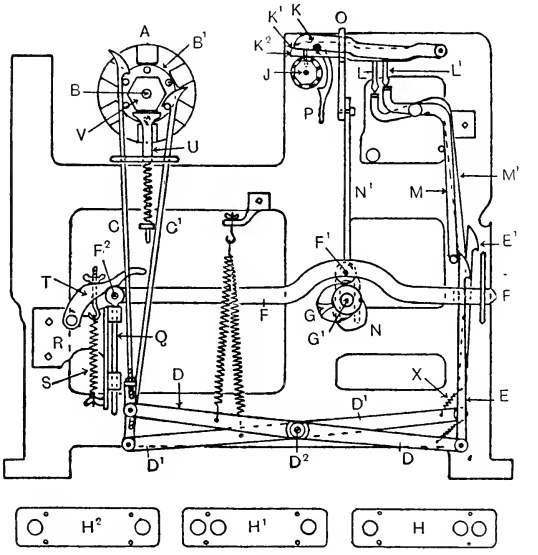


FIG. 44.

K and K^1. As the grid is raised by the eccentric the tumblers are also lifted, and by means of the catch P engaging with the dished head of the cylinder another card is brought into position.

An escape motion is provided at the heel of the lever F to prevent breakages, when the boxes are locked through any defect in their operation. The lever is pivoted to the head of the rod Q, which works in the sockets of the

bracket R. The spring S exerts sufficient pressure on the curved lever T, which under normal conditions prevents the lever F from rising at the heel when the boxes are being turned. If, however, any obstruction should prevent the boxes from rotating, and the lever from rising at the upright catches, it would lift at the heel by overcoming the tension of the spring, which would draw the lever back into position immediately the eccentric G turns away from the pulley F^1.

A spring hammer U, working in contact with the disc V, is provided to steady the action of the boxes, and reduce the vibration when turning.

CIRCULAR SKIP-BOX MOTION.—The mechanism employed in this type of box motion varies slightly in construction from that already described and illustrated in Fig. 44. The general arrangement of the various parts is practically the same, but the chief points of difference may be stated as follows: Compared with the mechanism shown in Fig. 44, a spur-wheel is fixed on the box spindle to take the place of the pegged disc B^1. The draw-hooks C and C^1 are substituted by a duplex rack, the respective sides of which are made to engage with the spur-wheel as required. The two sides of the rack merge into one lever, which is pivoted at the bottom to a cross-lever similar to D and D^1. The nature of the movement imparted to the rack is twofold. (*a*) It is free to move laterally to allow of either side being put into gear with the spur-wheel, according to the direction in which it is desired to turn the boxes. (*b*) In order to turn the boxes, the rack must be drawn downwards. The rack is operated in exactly the same way as the draw-hooks, with this point of difference: the distance moved or the stroke imparted to the rack can be varied in order to turn the boxes one, two or three forward or backward. This is obtained by the method of attaching the upright catches E and E^1 to the

single cross-lever. The catches are not pivoted directly on to the end of this lever, but are first compounded with a short lever, which is attached to the cross-lever in such proportions of leverage that to raise one of the upright catches the rack is drawn down such a distance as to turn the boxes one forward or backward. With the alternate catch lifted, the stroke of the rack is doubled, and so two boxes are turned. Should both catches be indicated to be raised at the same time, then three boxes would be turned. Additional mechanism is necessary to put the rack in gear with one or the other side of the spur-wheel.

It will be observed that this type of box motion affords greater scope for weaving fancy wefting plans, as any box of the set can be brought level with the race irrespective of its position in relation to the preceding shuttle.

THE WORKING OF CIRCULAR BOX MOTIONS.—Generally speaking, circular box mechanism demands more attention on the part of the tuner than box motions of the rising or drop-box class. This is primarily due to the increased speed at which the looms provided with the former class of box motion are run in comparison with looms provided with a box motion of the latter class. The mechanism in the circular box type is also more delicate in construction, and consequently more sensitive to any slight irregularity or failure of the working parts. The setting of the boxes is very important to ensure satisfactory working. They should be set in perfect alignment with the shuttle race and the reed. The boxes must also work squarely with the going part, by setting the additional connecting arm which couples the outer end of the boxes to the stud in the balance-wheel in perfect truth with the crank-arms, in order to keep the lateral movement of the boxes and going part in unison. Defective setting is a common cause of the shuttle flying out, as well as the boxes not working smoothly, as the shuttle

is thrown out when leaving the box, and not being properly checked when entering, by reason of its bearing heavily against the box side, the boxes cannot turn freely on account of the shuttle or picker impeding their movement.

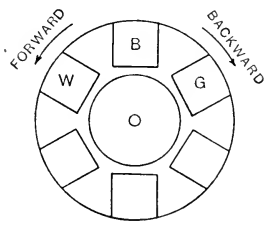
Timing the boxes is of equal importance to the setting. They should be timed so that they are not less than half-way turned when the crank is on the front centre and the reed beating up the weft. Any deviation from this general rule must only be effected in combination with any necessary alteration in the method of timing the picking and the shedding motions for reasons previously stated. When the boxes are timed to change with the going part in this position, the picker is or should be quite clear of the shuttle tip, and so allows them to turn freely in either direction. Any defect in this particular will be a productive source of trouble, and is one which is a very common cause of unsatisfactory working. The repeated contact of the shuttle with the picker soon wears a hole into the latter, so that if the shuttle when in the box is in close contact with the picker, before the boxes can turn the shuttle must be forced slightly forward into the box, in order to be in a favourable position for receiving the pick; this is done by the sheer force of the box motion overcoming the tension exerted on the shuttle in the box. If the shuttle fits the box fairly tightly it is prevented from sliding forward readily, with the result that the boxes cannot turn freely, and consequently they do not complete their movement for the pick to take place. As a result the shuttle is either thrown out or only sent part way across the race, and is trapped in the shed. Occasionally the boxes only become half-way turned; then the picker comes in contact with the end of the shuttle-box, and the loom is stopped or the picking arm or picking strap is broken. With reference to the above

remarks, the strength of the pick when driving the shuttle into the box has a decided influence. The force of the pick should not be too excessive, but should be regulated to drive the shuttle across the race into the box, but not to jamb the picker full up to the end of the picker spindle, or the defect referred to will be accentuated—*i.e.*, the shuttle tip will be in close contact with the picker, and the shuttle must be pushed forward before the boxes can turn.

Another important feature is the checking of the shuttle. The length of the check should be adjusted to the strength of the pick in such proportions that the shuttle will be checked with the tip clear of the picker; not with the picker driven back to its extreme position on the spindle. The relation of the shuttle to the picker must be such as to allow the latter to move slightly backward under the least possible pressure from the tip of the shuttle, so that the movement of the boxes will not be interrupted when bringing another shuttle into position. The manner in which the shuttles fit the respective boxes may easily act adversely to their movement. In the ordinary circular box loom the action of the draw-hooks may affect the timing of the boxes. The draw-hooks should be adjusted for length and position, so that no matter which hook is in action the boxes will be turned with the going part in the same position. In this type of box motion the boxes are under no positive control during such time as they are being turned. The draw-hooks pull them round up to a given point, then immediately the projection on the disc, which works in contact with the spring hammer, has passed the highest point, the boxes move quickly forward in advance of the draw-hook, by reason of the pressure of the spring hammer. This may have a detrimental effect on the working by reason of the vibration which takes place if the tension of the spring is excessive.

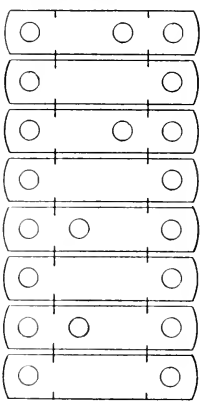
PATTERN CHAINS.—The style of pattern chain card used for the ordinary circular box loom is shown in Fig. 44. The method of building up a pattern chain is shown

WEFTING PLAN, No. 1.



Black = 4 4
Grey = 4 16
White = 4

Position of Shuttles at Start.



Box Chain.	Movement.	Shuttle.	No. of Picks.	
	Forward	B	2	4
	Stationary	B	2	
	Forward	G	2	4
	Stationary	G	2	
	Backward	B	2	4
	Stationary	B	2	
	Backward	W	2	4
	Stationary	W	2	

FIG. 45.

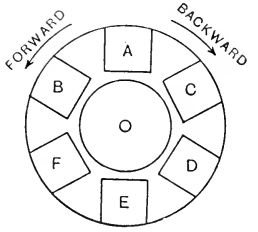
in Fig. 45, which is the chain required for the accompanying wefting plan No. 1.

Wefting plans containing six colours must be symmetrical in their arrangement, or they cannot be woven in this

type of loom—*i.e.*, the shuttle carrying the colour next required must be one forward or backward of the box

WEFTING PLAN, No. 2

A=24 24 24
B= 4 4
C= 4 4
D= 24 2 2 24
E= 2 2 2 2
F= 2



Position of Shuttles at Start.

Movement.	Shuttle.	No. of Picks.
Forward.	A	24
Backward.	B	4
Forward.	A	24
Forward.	C	4
Forward.	D	24
Forward.	E	2
Backward.	D	2
Forward.	E	2
Forward.	F	2
Backward.	E	2
Backward.	D	2
Forward.	E	2
Backward.	D	24
Backward.	C	4
Backward.	A	24
Backward.	B	4

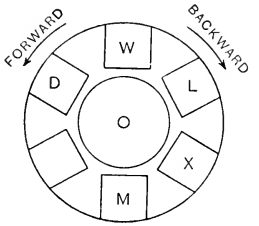
level with the race. Wefting plan No. 2 is a typical example of this arrangement of the shuttles, the direction of movement being given.

Occasionally wefting plans containing four or five dif-

ferent colours in which the order of the colours is not symmetrical may be woven in this loom. This is accomplished by employing more than one shuttle on certain of the colours. An example of this is given in the wefting plan No. 3, which could not be woven with four shuttles

WEFTING PLAN, No. 3.

White =32 32 32 32
Light Grey = 6 6
Mid Grey = 6
Dark Grey = 6



Position of Shuttles at Start.

Movement.	Shuttle.	No. of Picks.
Forward	W	32
Forward	L	6
Forward	X	32
Forward	M	6
Backward	X	32
Backward	L	6
Backward	W	32
Backward	D	6

X denotes No. 2 white weft.

only, as the dark grey is more than one box from the white which precedes it. If two shuttles are employed for running in the white weft, the order is reduced to one of a simple character. The boxes work forward four times in succession, then four times backward. The second shuttle indicated by the cross is run in equal proportions with the other shuttle carrying the white weft.

CHAPTER VII

LET-OFF MECHANISM

THESE motions are employed for regulating the amount of warp delivered from the warp beam, and also to maintain the necessary tension on the warp during the time that shedding and beating-up take place. The let-off motion has a direct influence on the number of picks per inch put in the cloth, being subsidiary to the take-up motion. There are two common classes of let-off motions, each class containing different types, the principle involved and the construction of each type in the two classes being practically the same. These motions are classified either as negative or as positive let-offs. The former term is theoretically correct, but is practically a misnomer, since the construction of this class of motion is such that it is solely employed for the purpose of keeping the warp in tension, and it does not in any definite manner let off the warp, the latter being drawn from the warp beam as required. Motions classed as " positive " differ from the former in that the warp beam is actuated mechanically in order to let off the requisite amount of warp, the motions being automatic in their action. These motions, however, do not necessarily give off exactly the same length of warp for each pick, but are so constructed that they are sensitive to variations in the tension on the warp, which is brought about by any cause—*e.g.*, the difference in the counts of the weft yarns, as when weaving fancy

vesting fabrics spotted by means of extra silk weft or other yarns of much finer counts than those used for the ground.

Various attempts have been made to construct a positive let-off the principle of which was to draw the warp off the beam by means of drawing rollers. The rollers were driven by a train of wheels in a manner similar to a positive take-up motion, suitable provision being made for regulating the let-off of the warp to the take-up of the piece in correct relation to each other, as occasioned by the variation in the shrinkage of the different weave structures, counts and quality of yarns, and in the number of picks per inch in different cloths. It is chiefly on account of these varying factors, and of the difficulty experienced in taking back the exact amount of warp after picking out, and at the same time preventing a shady place in the cloth, that this class of motion has not been adopted.

A let-off motion should possess the following features: Uniform tension should be maintained on the warp during the cycle of motions attendant on each revolution of the crankshaft. Provision should be made for regulating the motion necessitated by reason of the decreasing diameter of the warp on the beam, from the commencement to the finish of the warp. It should provide a ready means for taking back the warp on to the beam after unweaving for any defect. The motion should be sensitive, and readily respond to any variation in the tension of the warp.

NEGATIVE LET-OFF MOTIONS.—These are referred to in different terms—namely, brake, friction and twitch rope let-off. The principle is the same in each, the difference being in the method of application. The warp beam is supplied with suitable ruffles, one at each end, to which a brake may be applied, usually a steel band

lined with leather; or the ruffle may form part of a friction clutch, in which the requisite pressure is applied through the medium of levers and weights. The method most generally adopted is to employ stout hemp ropes or chains in combination with levers and weights. Fig. 46 shows an arrangement of this latter type. The rope A is first secured to the cross-rail B, then passed up behind the ruffle C, around which it is coiled a number of times, according to the tension required on the warp. It is finally secured to the ratchet D on the lever E, which is weighted by means of the weights F. This type of motion is generally adopted for broad looms engaged in weaving woollens, blankets, and other plain heavy fabrics. Another type of this motion adopted for narrow looms is illustrated in Fig. 47. A chain A is substituted for the rope. The position of the weight lever is as shown, but the principle in each of the motions is the same.

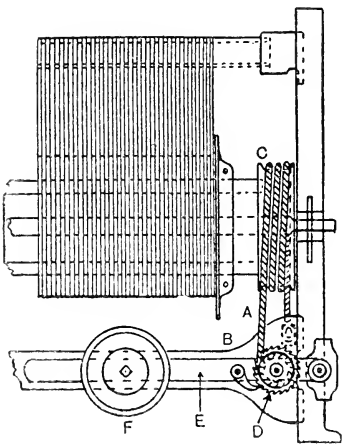


FIG. 46.

VARYING THE TENSION OF THE WARP.—Such motions afford ample scope for regulating the tension on the warp as may be required for different cloths, also for maintaining a uniform tension on the warp from a full to an empty beam. The tension may be varied by any of the following methods: By utilizing one or both ruffles on the

beam; increasing the number of coils on the ruffles; adjusting the position of the weight on the lever; or by means of additional weights. In the looms employed for weaving the heavier class of fabrics, two back rails are employed at the back rest, the warp being interlaced as shown in Fig. 47. This is a very useful arrangement, as the tension due to interlacing the warp in this manner reduces very considerably the friction to be applied by means of the ropes or chains on the ruffles; this also renders the motion more sensitive to the varying strains on the warp. There is a limit, however, to which additional coils can be made effective; if the ropes are coiled too frequently around the ruffles, and excessive weight placed on the levers, the delivery of the warp will be very irregular. This is due to the ropes maintaining their grip on the ruffles without allowing the warp beam to slip forward; consequently the weight lever is gradually raised and the rope is slackened between the beam and the cross-rail, until the friction between the coils and the ruffle is no longer sufficient to keep the warp beam in check; the beam then moves quickly forward, delivering an indefinite length of warp, which allows the levers to drop and the ropes to regain their grip. This process is repeated again and again, with the result that the numbers of picks per inch are irregular, and the piece is very shady weft way. For this reason it will be found that equal friction applied on each ruffle yields better results than having excessive tension on one and the other only lightly tensioned.

Causes of Defective Working.—The above features outline the chief defect in this class of let-off motion, which is in the main the cause of dark and light places in the cloth. This defect may also be traced to the ropes becoming dirty and greasy through usage. Owing to the tension exerted on the ropes they are speedily drawn and

worn into a practically solid strand, and when in this condition they are not so effective as when new. In order to overcome the irregular grip of such ropes a free use is made of powdered plumbago, but unless great care is exercised in its application, the defect it is intended to remedy will be rendered worse.

No doubt the most important factor in connection with the use of ropes is that they are adversely affected by the

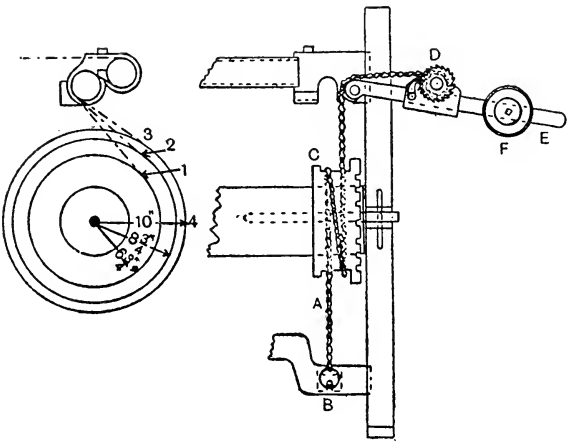


FIG. 47.

oil thrown off by the picking tappets and cones. In looms where the picking mechanism is placed inside the loom frame, as is the case in many of the plain looms fitted with the cam and cone type of picking motion, the rope when coiled around the ruffle is in close proximity to the picking mechanism. Much of the surplus oil is thus thrown off on to the ropes and ruffles, and this result has been frequently the direct cause of uneven pieces. A further defect in the use of ropes is that they are affected

by changes in the temperature of the weaving shed, such changes increasing or diminishing their grip on the beam and resulting in the irregular delivery of the warp between one portion of the piece and another.

It is with the object of overcoming this defect that chains have been substituted for hemp ropes, as they are not affected by any change in the humidity. There is one feature in the use of chains which is worthy of special consideration. Some tuners prefer to use chains without applying any oil or other lubricant, as they claim that a very regular grip can be maintained between the chain and the ruffle, providing that the latter is turned up true and smooth. No doubt this practice is permissible, but the difficulty is in keeping them perfectly dry throughout. They are not only liable to receive the surplus oil thrown off by the picking or any other mechanism of the loom, but the indiscriminate weaver will often apply oil with the object of increasing the production. For this reason it is much safer to lubricate the chain and ruffle, with either tallow or vaseline, at the commencement of a new warp, and so mitigate the possibility of surplus oil falling on them during weaving. A defect more common in light wefted fabrics is due to uneven shedding by reason of one or more of the heald shafts being lifted too high or drawn too low. An irregular lift of the healds in the formation of the shed is often sufficient to cause the warp to be jerked forward, as the warp beam is only lightly tensioned, the defect being more in the nature of a crack or incision across the piece than one of shadiness.

Advantages and Disadvantages of this Class of Motion.—The advantages of this class of let-off motion are to be found in the simplicity of their construction; their suitability for light and medium weighted cloths; their adaptability for weaving tender warps and those made from yarns possessing few elastic properties. This

latter is made possible on account of the oscillatory movement which is imparted to the warp, simultaneously with the strain of shedding and beating-up. Occasionally for this purpose the back rest is so constructed as to vibrate and yield to these varying strains, the oscillation being obtained by means of a swinging back rest, operated by a suitable lever actuated by a cam fixed on the crank-shaft. The disadvantages may be summarized as follows: Expenses incurred in the renewal of ropes; the difficulty experienced by the weaver when taking back the warp on to the beam after picking out, and also of regulating the tension on the warp in order to start up without showing a shady place in the piece; and the amount of attention demanded from the tuner or weaver to adjust the weight as required by the decreasing diameter of the warp on the beam.

The last of these factors is a constant source of defective pieces. The grip on the ruffles must be gradually diminished, in relation to the decreasing leverage which the warp line possesses at various stages. This is further explained by reference to Fig. 47, in which the lines 3, 2, 1 represent the position of the warp line at the start of each cut in a three-cut warp. The leverage from the centre of the beam to the point 4 is 10in.; this leverage at the end of the first cut is reduced to $8\frac{3}{4}$in., and at the end of the second cut to $6\frac{3}{4}$in. From these approximate figures it will be evident that if the force of the beat-up and the strain due to shedding are equal throughout the warp, the beam will be drawn round much more easily at the commencement, or during the first cut, with a leverage of from 10 to $8\frac{3}{4}$ in., than during the last cut, with a leverage of from $6\frac{3}{4}$ to 3in., which is the radius of the beam. Defects due to the above are most prevalent when weaving fabrics containing a few number of picks per inch, and are always accentuated in the last cut off the warp. From

observations made it was found that many of the pieces defective in this particular were the last cut off the beam. This is readily explained when it is remembered that the decrease in the diameter of the warp changes much more quickly during the last cut than during the first, the proportion being as 3 to 1. In such defective pieces the worst examples of these defects were found to be more noticeable in the last 10 to 15yds. of the piece. For this particular class of fabrics it is an advantage to use cased beams, say with a diameter of 8in., in preference to solid beams of about 6in. diameter, as there would not be such a marked difference in the changing diameter during the last cut off the beam.

Positive Let-off Motions.—The construction of the different types of these motions varies only in matters of detail. The principal features involved are the sensitive back-rest over which the warp is passed, and the method of operating the let-off shaft.

The construction of a type of positive let-off motion is illustrated in Fig. 48. The worm-wheel A fixed to the warp beam is made to gear with the worm B on the let-off shaft C. This shaft is supported in suitable brackets fixed to the loom frame, usually on the inside, the back bracket shown at D being made in cup form for the purpose of retaining a quantity of oil, in which the worm rotates. On the shaft C a ratchet wheel E is secured, the ratchet being actuated by means of the catches F and F^1, which are supported in the catch-box G fulcrumed on the let-off shaft. The catches are made of different lengths, the catch F being half the pitch of the teeth in the ratchet wheel longer than F^1. This provision renders the motion more sensitive to any variation in the tension applied to the warp. The shaft C is prevented from turning too freely by means of a brake strap acting on the brake wheel H. The catches are operated from the crankshaft

by means of the eccentric J and the cranked lever K, the lower arm of this lever being connected to the catch-box by means of the rod K^1. The stroke of the catches, and consequently the amount of warp let off, is determined as follows:

(*a*) By the length of the regulating rod L, which is secured at one end of the lever K, and at the other end, which is provided with a slot, to the stud L^1 in the back-

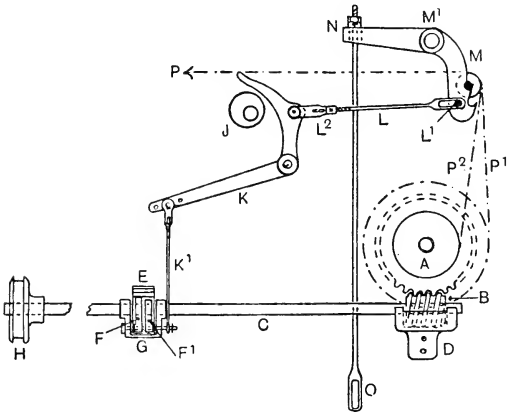


FIG. 48.

rest bracket M. The length of the rod can be easily altered by slipping it off the stud L^1 and screwing it farther into or out of the screw-threaded bracket L^2.

(*b*) By the movement of the back-rest M, which has its fulcrum on the stud M^1. The upper arm of the back-rest M is suitably connected to the weight lever by means of a connecting rod at the points N and O respectively.

The movement of the back-rest bracket is influenced by the tension applied on the warp at the time when beating-up takes place. The force of the beat-up draws

the warp in the direction indicated at P, and simultaneously causes the back-rest to move inwards; this allows the rod L to work forward, and the lever K and the catch-box to fall, with the result that the catches engage with the teeth of the ratchet wheel at a lower point than would be possible if there was no movement of the back-rest. It should be noticed that the cam J on the crankshaft is so fixed that the throw—*i.e.*, the swell of the cam—has worked clear of the lever K when beating-up is taking place, and therefore permits the lever and the catches to drop to the full extent, as determined by the movement of the back-rest. It will be obvious that any weight on the weight lever will result in great resistance to the movement of the back-rest, and consequently will increase the impact during beating-up of the weft, and *vice versa* with a reduced weight on the lever at O. The successful working of this class of motion depends on maintaining a correct relation between the stroke of the lever K and the movement of the back-rest M, as the requisite amount of warp may be let off with more or less movement of the back-rest. If the stroke given to the lever K from the cam J is not sufficient to rotate the ratchet wheel and let off the necessary amount of warp, the tension on the warp will quickly increase, drawing forward the back-rest and lifting the weight lever, thereby increasing the stroke of the lever K, so that the catches take more teeth of the ratchet wheel. To avoid this the motion should be regulated by means of the rod L, which must be lengthened in order to give a greater stroke to the lever K with less movement of the back-rest. On the other hand, this should not be carried to the extreme until very little movement of the back-rest is perceptible. The best results are obtained when the motion is set so that the weight lever rises and falls regularly at the beat-up. When the proper relation has once been obtained, the

motion will yield very satisfactory results, as any tendency for the warp to increase in tension is indicated through the sensitive back-rest to the lever K, whilst any slackening in the tension is taken up by reason of the weight lever drawing down the rod N, and moving the back-rest and the stud L^1 to their backward position, which shortens the stroke of the lever K and reduces the amount of warp let off.

This particular feature might appear to be a rather defective arrangement—namely, that the regulation is obtained after the tightening or slackening of the warp has taken place. With careful setting at the commencement of a warp the motion can be made very sensitive and to respond to any slight variation in the tension, therefore immediately correcting its action before any defect is produced in the woven fabric.

Regulating this Class of Motion.—It must not be inferred from the foregoing remark that no regulating of the motion is necessary from the commencement to the finish of a warp. The writer has, however, had experiences with warps of very fine counts, one and two cuts in length, which have been woven without the motion rod or the weight on the lever requiring any adjustment throughout the warp. There are two factors which have a direct influence on the amount of attention necessary to keep this class of motion working uniformly throughout the warp. The first is the alteration in the diameter of the warp from a full to an empty beam, and secondly, the alteration in the direction of the resultant of the forces P and P^1 when the beam is full, to the resultant of the forces P and P^2 when the beam is nearly empty.

Obviously the warp beam must travel quicker as the diameter decreases in order to let off the same amount of warp. This, as already explained, should be effected by regulating at the motion rod L, giving a greater traverse

to the catches and the let-off shaft, without the movement of the back-rest being increased, which would be the inevitable result if any adjustment of the motion is ignored. This particular feature is most noticeable when weaving warps of thick counts, with extreme diameters of the warp beam, and which vary more quickly than in warps of finer counts.

It will also be observed that the weight lever will be lifted more easily as the angle formed by the warp line P, P^1, and P, P^2, becomes more acute. This necessitates a slight increase in the weight on the lever at O as the warp beam empties, in order to maintain uniformity in the force of the beat-up throughout. The above conclusions will be found to obtain in actual practice—namely, as the diameter decreases, the motion rod requires letting out and the weight in the lever increasing, in order to keep the movement of the back-rest and the resistance to the beat-up regular and uniform.

An improved type of this class of let-off motion is shown in Fig. 49, the principle being now employed on most modern looms. The development of this type of motion from the former consists in the introduction of a shield A, fixed to the lever A^1, which works between the ratchet wheel B and the catches C and C^1, the latter being supported on the toothed quadrants D and D^1 on either side of the ratchet wheel. The quadrants are geared with the double quadrant lever E, which is operated from the lay sword, to which it is connected by means of the rod F. The above parts are shown more in detail in Fig. 50; which shows a front elevation of the double quadrant E; a side elevation of the front quadrant and the ratchet wheel in the upper right-hand diagram; and a side elevation of the shield and ratchet wheel in the lower right-hand diagram.

It will be observed that the movement of the catches is

a reciprocating one; and without any interposition of the shield they would engage with the ratchet wheel, and cause the let-off shaft to travel at a uniform rate. The shield A, constructed of sheet metal and semicircular in form, is employed to regulate the amount of warp to be let off;

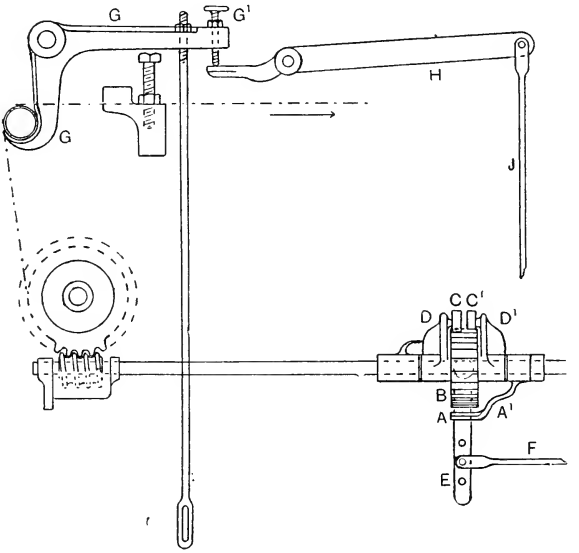


FIG. 49.

its action is governed by the movement of the back-rest G. Any movement of the back-rest is transmitted through the medium of the lever H and the rod J to the shield, which, as already indicated, is influenced by the variation in the tension on the warp. If the tension is increased, the back-rest is drawn inwards, raising the regulating screw G¹; this allows the lever H to lower the connecting rod and the shield, and as the latter is with-

drawn, more of the teeth in the ratchet wheel are exposed to the catches. Similarly, with any slackening of the warp the back-rest is drawn in the opposite direction, raising the rod J and interposing the shield between the catches and the ratchet wheel, and so reducing the amount of warp let off.

The following advantages can be claimed for this motion over the former type: On account of the catches

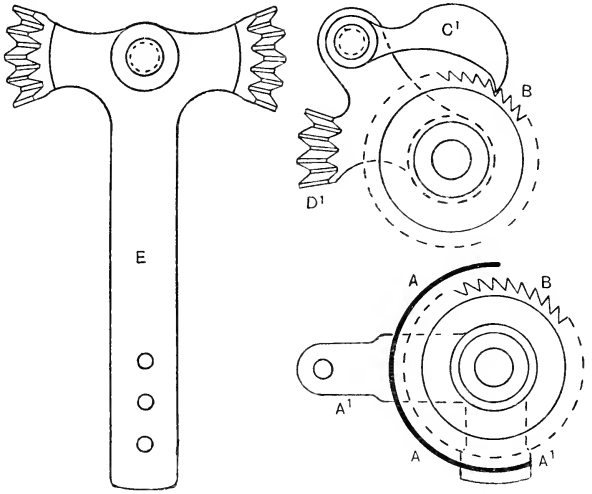


FIG. 50.

being duplicated and operating alternately, the warp is let off more regularly and in smaller quantities, whilst the shield, and not the catches, only being operated from the back-rest, the motion is more sensitive in its action.

A more recent addition to this class of let-off motions is a type in which provision is made for turning the warp back on to the warp beam when unweaving for any defect in the cloth. The object of this improvement is to make

the motion entirely automatic in its action by reason of the weaver not being required to turn the warp back by hand in order to regulate the tension on the warp prior to restarting weaving.

The principle and the construction of the chief parts in such a type of motion are shown in Fig. 51. This motion has many points in common with other types of this class, but can only be employed in combination with a positive take-up motion. Fixed to the let-off shaft A are two ratchet wheels B and B^1 set with their teeth in opposite directions. Two catches C and C^1 are employed for operating the ratchet wheels B and B^1 respectively. The catches being attached to the upper arm of the lever D, which is actuated from the lay sword, have a reciprocating motion imparted to them. A shield E operated from the sensitive back-rest is interposed between the catches and the ratchet wheels. When the shield is in its middle position as shown, both catches are prevented from engaging with their respective wheels. As the tension on the warp increases, the shield is withdrawn from under the letting-off catch C, allowing it to engage with the ratchet wheel B; during this time the taking-back catch C^1 works backward and forward on the top of the shield. The catches are dovetailed into each other, and held together by means of a spiral spring C^2, such provision being necessary to allow of both catches being disengaged at the same time when necessary.

When, for any reason, unweaving has to take place the pattern lags and the take-up motion are first reversed, then the weft removed as the loom is turned over pick by pick. Immediately the tension on the warp is released, the weight lever gradually draws down the back-rest, and at the same time reverses the position of the shield. This disengages the letting-off catch and allows the taking back catch C^1 to engage with the ratchet wheel

B^1, and so winds back the warp on to the beam. It will be observed that this motion can only be applied to those looms in which unweaving is effected by the loom being turned over pick by pick, as in the Hattersley loom, the makers of which are the patentees of this particular type of motion.

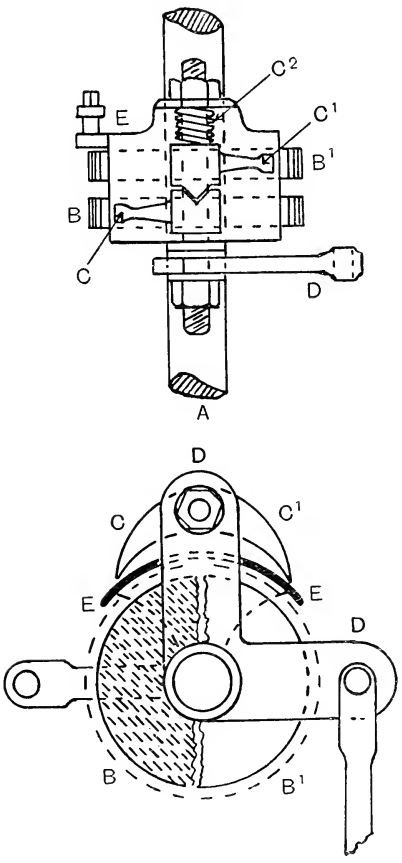


FIG. 51.

Positive let-off motions are no doubt better adapted to the requirements of heavy and medium fabrics. They are, however, not so well adapted for weaving light wefted cloths, as the regular movement of the back-rest is largely controlled by the beating-up of the weft, which in a light wefted cloth is insufficient for this purpose. This class of motion also requires less attention on the part of the tuner.

The following is a summary of the causes of defective pieces due to defects in the letting-off motion,

the remedies for which are obvious: The beam wheel springing out of gear with the worm; the beam wheel and worm short of oil; defective brake strap due to the presence of grease or dirt; irregular movement of the back-rest; the catches missing when they are worn down or the teeth in the ratchet wheel worn down or broken; strained warp beam shaft; and tampering with the motion on the part of the weaver.

CHAPTER VIII

TAKE-UP MECHANISM

THE function of a take-up motion is to draw the cloth forward as it is woven. The operation is performed by means of a taking-up roller actuated by suitable mechanism in such a manner that the cloth is drawn forward regularly. The various types of these motions may be divided into two classes—namely, negative and positive. In the former class the principal feature is the method by which motion is imparted to the taking-up roller, the amount of cloth drawn forward at each pick being determined by the force applied by the reed to the fell of the cloth at the beat-up. It is only as the cloth is pushed forward by the reed that it is possible for the motion to register any take-up. In the latter class the taking-up roller is driven in a positive manner by a suitable train of wheels actuated from some convenient part of the loom, so that the same length of warp is drawn forward for each pick of weft inserted.

Another feature of difference in the construction of the two classes of motions is as follows: In the negative motions only one taking-up roller or cloth beam is employed, which performs the double function of drawing the cloth forward as it is woven, and at the same time winding it on to itself. In the positive motions there are two rollers—the taking-up roller, which is employed solely for drawing the cloth forward, and the cloth beam on to which the cloth is wound.

NEGATIVE MOTIONS.—The construction of a type of this class of motion is illustrated in Fig. 52. To the shaft of the cloth beam A the spur-wheel B is secured, the latter being geared with the pinion wheel C which is compounded with the ratchet wheel D. The latter is actuated by the pawl E, which is attached to the upper arm of the three-armed lever F fulcrumed at F^1. Motion is imparted to the lever F in one direction by means of the stud G which is fixed in the lay sword. A forward movement of the lever and pawl is obtained by reason of the weight H on the arm of the lever F overcoming the tension or pull of the piece at the time when the reed J is beating up the weft. The retaining catches K are necessary in order to prevent the motion from reversing owing to the tension and pull of the piece being again applied immediately the reed recedes from the fell of the cloth. This type of motion is largely employed on plain tappet looms weaving medium and heavy woollens and union fabrics, for which it is specially adapted on account of the quick movement which may be imparted to the cloth beam when weaving fabrics containing few picks per inch. This feature is made possible by reason of the movement of the ratchet wheel being transmitted directly to the cloth beam through the medium of the pinion wheel C.

Fig. 53 illustrates another type of negative motion somewhat different in construction from that already described. It is better adapted for weaving cloths containing a large number of picks per inch, the ratio of the first driver to the last follower being increased by the introduction of an intermediate wheel and pinion. The cloth beam A supported by the arbors A^1 is provided with a spur-wheel B which is in gear with the intermediate pinion C. This pinion is secured to the shaft of the intermediate wheel D, which in turn is geared with the ratchet pinion E compounded with the ratchet wheel F. The

ratchet wheel is actuated by means of the pawl G attached to the upper arm of the lever J, the lower arm J^2 being in contact with the stud L fixed in the lay sword, from which it is operated in one direction. When the

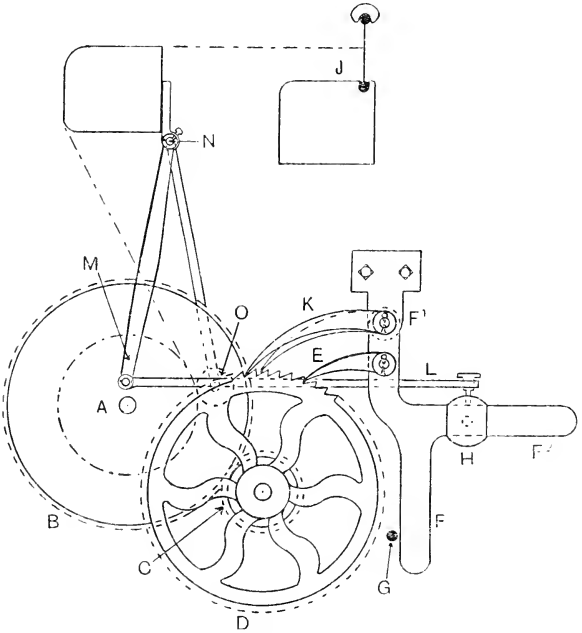


FIG. 52.

tension on the piece is relieved at the beat-up, the pawl, assisted by the weights K, and in some instances by means of a spiral spring substituted for one or both the weights, draws the ratchet wheel forward, and so winds the cloth on to the beam. The various parts of this motion are suitably carried in the bracket M bolted to the loom frame; the retaining catches are shown at H.

The successful working of this class of take-up motion

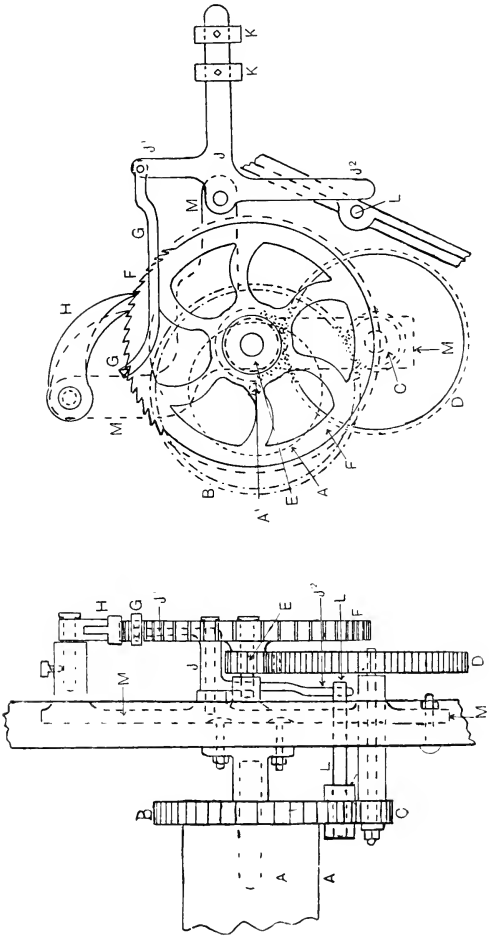


FIG. 53.

depends upon the maintenance of correct relation between the tension on the cloth at the time when the beat-

up takes place and the action of the taking-up lever. This is more readily understood if the following factors are taken into consideration: The tension of the cloth exercises a force which acts through the train of wheels in the direction opposite to the taking-up lever. Further, this force increases with the gradually increasing diameter of the cloth beam, consequently more weight, or its equivalent, the substitution of a spring, must be applied to the taking-up lever. It might be assumed that as the reed works forward to the same point at each beat-up the resistance offered to the take-up motion due to the tension on the cloth is always uniform. It should be observed, however, that the tension on the cloth between the fell of the cloth and the cloth beam is never entirely overcome; for when the reed is in contact with the fell of the cloth there must always be sufficient tension on the warp to resist the beat-up and obtain the requisite number of picks per inch. In addition, the motion needs some slight regulation by reason of the increasing weight of the piece beam, due to the addition in the length of cloth woven.

Automatic Regulating Motion.—For the purpose of regulating the motion automatically several mechanical contrivances have been introduced. The construction and principle of such a motion are shown in Fig. 52. The weight H is caused to slide along the arm F^2 of the taking-up lever by the rod L pivoted on the weight and to the lever M. This latter lever in turn is secured to the outward end of the rod N, which extends some distance in front of the breast beam. The rod then extends downwards, and is again cranked to carry the wooden roller O, which works in contact with the cloth beam. As the diameter of the cloth beam increases the roller is forced outwards, and at the same time the weight is moved further along the arm of the lever, thereby yielding the

increased power necessary to actuate the take-up motion.

When the relation between the tension of the cloth and the weight is once obtained, any slight discrepancy in the take-up is quickly corrected. If the motion is not setting up quickly enough the reed comes in contact with the fell of the cloth sooner, and the tension is relieved to a greater extent, this being attended by a corresponding increase in the take-up. Similarly, any excess of setting up would correct itself by reason of the beat-up decreasing in force, and the slackening of the piece not being sufficient to allow any take-up to be registered until the tension again became normal.

Features of Negative Motions.—This class of motion is most advantageously employed for heavily wefted goods. These are liable to slip on the friction roller of a positive take-up motion, and are therefore better woven with a negative motion, where the piece is wound direct on to the cloth beam. It is also preferable for weaving cloths in which the weft yarns are of different counts, also in fancy vestings and similar fabrics in which the picks per inch vary on account of the extra silk spotting picks. This class of motion is unsuitable for weaving lightly wefted goods in which the reed is not required to beat up the picks, but merely to push them into position with the preceding picks. In the absence of the beat-up the motion requires more attention from the weaver if the picks per inch are to be kept uniform. Frequent measurement of the picks should be made, as under the above conditions the motion may vary the number of picks inserted per inch very considerably. The weaver should be warned against tampering with the amount of weight on the taking-up lever, as it is a very common practice for the weaver to keep a supply of weights, consisting of parts of broken loom

castings, by means of which some alteration in the number of picks per inch may be effected without in any way regulating the let-off motion. The amount of weight on the taking-up lever should always be attended to when starting a fresh piece. It is the practice, when one piece follows another out of the same warp, to weave what is called a " lapping-on " into the succeeding piece, usually from two to three yards; the full piece is then pulled off the beam, and the lapping-on length used to start again for the new piece. Unless there is a reduction of the weight on the taking-up lever to compensate for the reduced diameter of the cloth beam a reduction in the number of picks per inch will inevitably take place. In order to avoid this the tuner should make it a condition for the weaver not to proceed with the next piece until the weight has been regulated and the picks per inch have been counted.

Positive Take-up Motions.—There are several well-known types of this class of take-up motion, the principle involved in each being practically the same. The construction of the various types only differs in minor details, the method of imparting motion to the train of wheels employed for driving the take-up roller being the chief point of difference. Some motions are driven intermittently by means of a pawl and ratchet wheel; others are driven continuously by means of a worm and worm-wheel.

A type of an intermittent motion is illustrated in Fig. 54. The take-up roller A, frequently referred to as the friction roller, feed roller, sand roller or the " gratter," is clothed with perforated sheet metal, which is wound round the roller with the rough side outward, for the purpose of increasing the grip on the cloth to prevent slipping. To the shaft of this roller a spur-wheel B is secured, this being geared with the pinion wheel C

compounded with the intermediate wheel D; the latter is geared with the wheel E, which is the change-wheel of the motion, this being secured to the shaft of the ratchet wheel F. To operate the ratchet wheel a pawl G is employed, which is pivoted on the swing lever H; this in turn receives motion from the stud J attached to the lay sword and working in the slot of the lever H. Tracing out the method of working, it will be observed that the ratchet wheel is pushed forward by the pawl simultaneously with the forward movement of the lay sword. Usually the stroke of the pawl is such as to move the ratchet wheel one tooth forward at each pick, although by altering the position of the stud J in the slot of the lever, two teeth of the ratchet wheel may be taken by the pawl at each stroke. The piece is drawn forward by the take-up roller, round which it is passed until it reaches the guide bar K, over which it travels on to the cloth beam, the latter being driven by frictional contact with the take-up roller; the requisite pressure is obtained by means of chains and weights.

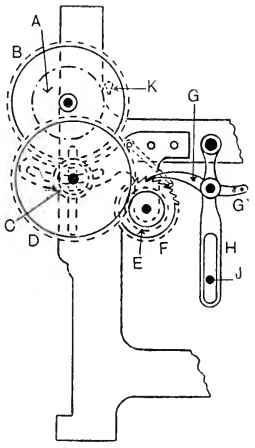


FIG. 54.

A continuous type of a positive motion is illustrated in Fig. 55. The take-up roller A is mounted with a worm-wheel A^1, driven by means of the worm B, this being provided with a sleeve bored to admit the shaft C, and which is supported in the brackets D, D^1, the hand-wheel E being fixed on the end of the worm sleeve. Provision is made for connecting or disconnecting the hand-wheel

and the worm to the shaft C by means of the knob F, as shown in the sectional drawing in Fig. 56. Fitted to the end of the shaft is a short arm G; this is bored to receive the pin H, which forms part of the knob. The face of the hand-wheel is provided with a series of holes at equal distances apart, into any of which the pin on the knob may enter, being held in position by means of the spring J. When the pin enters one of the holes the hand-wheel

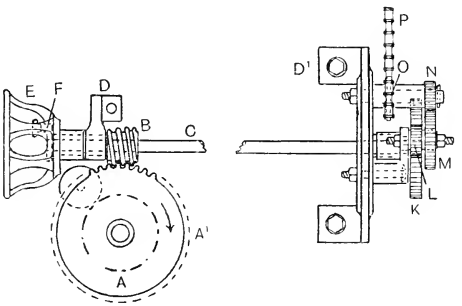


FIG. 55.

and the worm must travel with the shaft C, this being driven by a train of wheels as follows: To the end of the shaft the spur-wheel K is secured, this being geared with the pinion wheel L compounded with the change-wheel M; the change-wheel is geared into the star-wheel pinion N, which is compounded with the star-wheel O. Continuous motion is imparted to the train of wheels from a star-wheel, secured to the reversing shaft of the top cylinder, which drives the star-wheel O by means of a pitch chain P.

FEATURES OF POSITIVE MOTIONS.—The intermittent type of motion is best adapted for weaving fabrics figured by means of extra weft. As previously pointed out,

such spotting picks are considered as extra picks, unless the figure is continuous—*i.e*, where the figuring picks are arranged in some regular proportion with the ground as 1 and 1, 2 and 1, etc. This type of motion is specially suitable for this particular class of fabric owing to the facility with which the motion may be rendered negative in its action when the extra picks are being inserted. This is usually done by making some suitable connection from the short arm G^1 (Fig. 54) of the pawl to a jack in the dobby, or to the shuttle-box in which the extra weft shuttle is run, so that the pawl is lifted out of action with the ratchet wheel when the extra picks are put in. The chief defect of this type of motion is the liability to produce shady pieces, by reason of some irregularity in the take-up. This may be due to the pawl, the retaining catch, or the teeth in the ratchet wheel being worn down or broken, and therefore liable to miss.

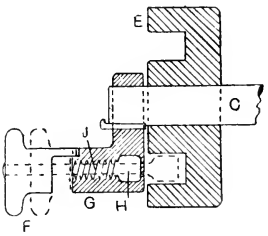


FIG. 56.

The continuous type of motion is rarely the cause of shady pieces, as the worm-and-worm-wheel method of driving the cloth beam is safer in action. A further advantage of this method of driving is obtained on account of the motion being actuated from the reversing shaft in the dobby. When the dobby is reversed by the weaver for the purpose of taking out the picks, the take-up motion is also reversed, so that the cloth is unwound from the cloth beam in the same ratio as it was wound on. This makes it much easier for the weaver to turn back the exact amount of warp on to the warp beam to prevent shadiness when the warp is not wound back automatically, as explained in the preceding remarks on let-off motions.

Some objections to the type of motion shown in Fig. 55 are as follows: The position of the taking-up roller in relation to the piece is such that it acts on the face of the piece, which in certain fabrics may be damaged. The position of the cloth beam in relation to the take-up roller is also such that the back of the cloth cannot be seen unless the piece is let slack for this purpose. It is an advantage, if not an essential, that the weaver should be able to examine the back of the piece, and especially in backed and double-cloth fabrics, as defects may be discovered which would otherwise run throughout the piece. It is worthy of note that the makers of this type of motion have overcome the above defects by altering the position of the take-up roller, which is now fixed immediately under the breast beam, the direction of rotation being also reversed.

Calculations for Take-up Motions.—For the purpose of effecting any alteration in the number of picks per inch, one of the wheels in the train is a change-wheel; this change-wheel may be either a driver or a driven wheel. In the type of motion illustrated in Fig. 54 the change-wheel E is a driver. Obviously any increase in the number of teeth in this wheel will result in the following wheels and the taking-up roller drawing the cloth forward more quickly, with a corresponding reduction in the picks per inch; whilst the substitution of a wheel containing a less number of teeth will increase the picks. For the purpose of finding the number of teeth the change-wheel must contain for a given number of picks per inch, it is customary to supply the tuner with the dividend number or gauge point of the motion. This is obtained by the following formula:

$$\frac{\text{No. of teeth in ratchet wheel F} \times \text{No. of teeth in inter. wheel D} \times \text{No. of teeth in roller wheel B}}{\text{No. of teeth taken by the pawl G at each pick} \times \text{No. of teeth in pinion wheel C} \times \text{Circum. of the roller A in inches}} = \text{Dividend number.}$$

Assuming the particulars for such a motion to be: Pawl taking one tooth of ratchet wheel per pick; the ratchet wheel, 60 teeth; the intermediate wheel, 120 teeth; pinion wheel, 30 teeth; roller wheel, 110 teeth; circumference of taking-up roller, 16in. The dividend number will be:

$$\frac{60 \times 120 \times 110}{1 \times 30 \times 16} = 1650.$$

Then to find the change-wheel, 1650 divided by the picks per inch required equals the number of teeth the change-wheel must contain. And conversely 1650 divided by change-wheel equals picks per inch. This motion is suitable for weaving cloths varying from 28 to 60 picks per inch. The series of change-wheels for these and the intervening number of picks per inch could be employed for weaving cloths containing less than 28 down to 14 picks per inch, by setting the pawl to take two teeth of the ratchet wheel forward at each pick. To avoid working out a separate calculation for each differently picked cloth, it is advisable for the tuner to work out a table of the picks per inch and a list of the change-wheels required; this should be posted up near to where the spare change-wheels are kept, for ready reference.

In the motion illustrated in Fig. 55 the change-wheel is a driven wheel. The velocity ratio of this train of wheels is so arranged that the number of teeth contained in the change-wheel indicates the picks per inch in the piece. The particulars for this motion are as follows:

First driver is the star-wheel on the top cylinder shaft, making one revolution per pick, and contains 8 teeth.

Second driver is the star-wheel pinion N	. . . .	= 20	teeth.
Third ,, ,, change-wheel pinion L	. . .	= 18	,,
Fourth ,, ,, worm B	. . . . .	= 1	tooth.
Fifth ,, ,, circumference of take-up roller A		= 20	in.
First driven wheel is the star-wheel O	. . . . .	= 8	teeth.
Second ,, ,, change-wheel M	. . . . .	= x	,,
Third ,, ,, shaft-wheel K	. . . . .	= 84	,,
Fourth ,, ,, roller wheel A^1	. . . . .	= 85	,,

The working for the above may be stated as follows:

$$\frac{\text{Drivers} = 8 \times 20 \times 18 \times 1 \times 20 \times (p = \text{picks per inch})}{\text{Driven} = 8 \times (x = \text{teeth in change-wheel}) \times 84 \times 85} = \frac{120\,p}{119\,x}$$

Therefore x, the number of teeth in the change-wheel, equals p, the picks per inch, when a small percentage for shrinkage in the piece is allowed, which takes place between the fell of the cloth and the taking-up roller; this shrinkage will vary slightly in different cloths.

An advantage of this motion is, that a very wide range of cloths can be woven from a small stock of change-wheels, a large star-wheel containing 16 teeth being provided for this purpose. This wheel may be substituted for the star-wheel on the top cylinder shaft to act as a driver, or be used in place of the star-wheel O as a driven wheel. When the 16 wheel is employed as a driver, the change-wheel indicates half the number of picks—*i.e.*, a 40 wheel would give 20 picks; when used as a driven wheel, a 40 change-wheel would give 80 picks. Assuming the highest and lowest change-wheels of the series in stock to be 60 and 30 respectively, a range of cloths could be woven containing as many as 120 picks with the 60 change-wheel down to 15 picks with a 30 change-wheel.

CHAPTER IX

AUXILIARY MECHANISM

With the object of making the power-loom more automatic in its action, various mechanisms have been introduced, the chief of which are the weft stop-motion, warp protector motion, warp stop-motions, and temples. In addition various patents are being invented from time to time the introduction of which makes the duties of the tuner more exacting; needless to say, such additional mechanism which does not justify its permanent adoption is quickly discarded.

Weft Stop-motion.—The function of this motion is to stop the loom when the weft supply fails or breaks. Such a motion is practically indispensable on fast-running looms engaged in weaving the more intricate and expensive fabrics. There are, however, many types of plain looms employed for weaving low woollen and union fabrics, on which weft stop-motions are not adopted.

There are two distinct types of these motions, known as the " side weft fork " and the " centre weft fork." A type of the former is illustrated in Fig. 57. The weft fork A fulcrumed on the rod B is made with the hooked end slightly heavier than the forked end, which consists of three prongs bent at right angles. The rod B is held in position by the knob of the pistol lever C, this being placed in close proximity to the starting lever D. The hooked end of the fork works over the snecked surface of the hammer lever E, the lower arm E^1 extending down-

wards and projecting over the low shaft F. On this shaft is fixed the cam G, which, making one revolution every two picks, lifts the lever E^1 and throws back the upper arm E on alternate picks. Fixed in the shuttle race at the entrance to the shuttle-box is a grid H, which contains three apertures to admit the prongs of the fork when the reed comes to its front position at the beat-up. The method of working is as follows: When the weft is present it is laid across the grid so that the prongs of the fork are prevented from entering freely, and as a result the fork is tilted just at the time when the hammer lever E is thrown back by the cam G. If the weft is missing, the prongs of the fork enter the grid, so that the hooked end is allowed to engage with the sneck in the surface of the hammer lever, which draws back the fork and the pistol lever C, and at the same time knocks the starting lever out of the retaining notch, transferring the belt on to the loose pulley. When the loom is stopped by the action of the weft fork, the brake motion is brought into operation to prevent the loom over-running; also the take-up motion is rendered inoperative, and in circular box looms the boxes are prevented from turning during the finding of the pick and replenishing the weft. From these particulars it will be readily seen how the weft stop-motion may be made to assist in no small measure in the production of a perfect piece.

Satisfactory working of this motion depends on accuracy of setting. The cam G must be set to lift the lever E^1 in unison with the beat-up, at which time the weft fork will be tilted by the presence of the weft, or allowed to engage with the sneck in the hammer lever E if the weft is missing. The tensioning of the weft in the eyelets of the shuttle needs very careful adjustment; if left too slack it would fail to tilt the fork. The fork should be set to allow the prongs to enter the

grid quite freely, and not touch the sides of the bars or the bottom of the groove cut in the race. The result of this would be for the fork to be tilted independently of the weft and not indicate when the weft had broken or become spent out.

This type of motion possesses the disadvantage that the weft fork indicates only on alternate picks, by reason

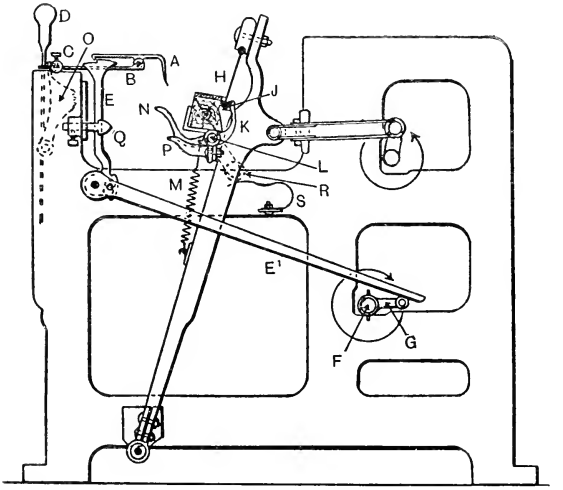


FIG. 57.

of its being placed at one side of the loom. On this account it is possible for the weft to break and catch on again during the return pick, which without giving any indication to the weft fork would allow partly broken picks to be made in the piece. By reason of the above defect this type of weft stop-motion is only adopted on looms employed for weaving plain calico, linsey, low woollens, and other fabrics, in which a broken pick is not considered a serious defect in the finished cloth.

CENTRE WEFT-FORK.—This motion, as the name implies, is fixed in the centre of the shuttle race, with the object of indicating on every pick. This is essential in the majority of woollen, worsted and other expensive fabrics in which broken and missing picks are considered as defects, and which must be remedied prior to the finishing of the piece. The construction of such a motion is illustrated in Fig. 58. In the centre of the race a groove is cut into which the weft feelers A may enter and so drop below the level of the race-board. The feelers are fixed in the winged bracket B supported by means of the screws C which are fixed in the arms of the bracket D secured to the front of the going part. A sliding bracket E on which are two inclined planes is placed to work beneath the wings B^1 and B^2. A lateral motion is imparted to the bracket E by means of the rod F, which is pivoted in the socket G secured to the breast-beam. As the going part moves backward the sliding bracket E is drawn in the direction of the arrow, and the inclined plane H engaging with the wing B^1 raises the feelers A; during this time the shuttle passes across the race, leaving a pick of weft beneath the feelers. As the going part again moves forward, the sliding bracket is forced in the reverse direction. The presence of the weft supports the feelers and keeps the wing B^1 clear of the notch E^1 cut in the inclined plane H; this allows the sliding bracket to move back to the extremity of its stroke. If, however, the weft is missing, the feelers drop into the groove, and the wing B^1 enters the notch E^1; this arrests the sliding bracket on its return movement in such a position as to stop the projection J, connected to the bracket by means of the rod K, directly opposite the finger L. As the going part comes forward the projection strikes the finger, which, being fixed to the pistol lever, dislodges the starting handle and so stops the loom. The spring F^1 is neces-

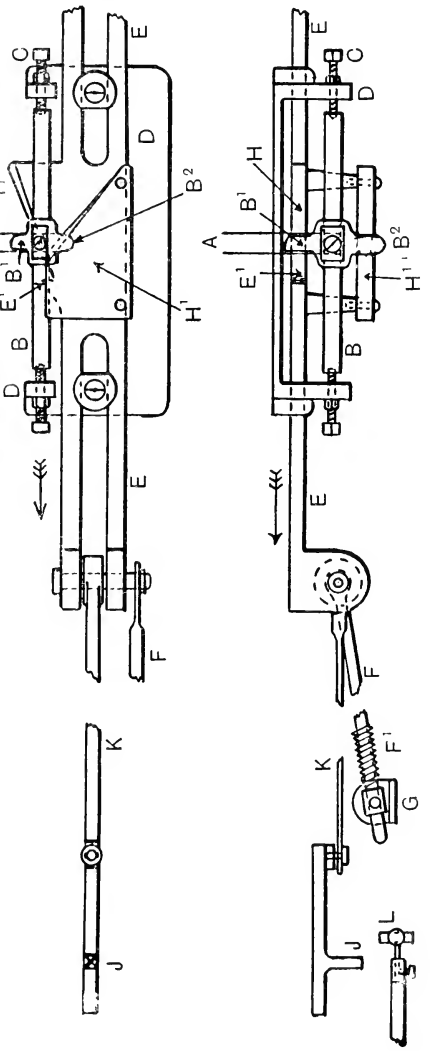


FIG. 58.

sary as an escape motion when the sliding bracket is locked by the absence of the weft; whilst the function of the inclined plate H^1 working in contact with the wing B^2, serves to prevent the feelers rising too high, also to make their downward motion positive until the level of the plate is reached, after which they are left quite free to drop into the groove, or rest on the weft pick until they are drawn off by the forward movement of the going part.

Defects due to Weft Stop-motions.—The weft may be cut if the prongs are set to pass too far through the grid or allowed to touch the sides of the bars. Weft loops may be the result of defective working or irregular tension on the weft; broken picks if the weft stop-motion fails, also short checks when weaving check patterns. Constant knocking-off of the loom due to imperfect setting and timing. The centre weft fork may be responsible for throwing the shuttle or tearing the piece if the feelers are not set to rise at the proper time.

Warp Protector Motion.—The object of this motion is to protect the warp from being broken if the shuttle through any cause is caught in the shed when the beat-up is about to take place. There are two general types of these motions, known as the "loose reed" and the "fast reed" warp protectors. An illustration of the former is given in Fig. 57, and is employed on most quick-running looms weaving light and medium wefted fabrics. The feature of this motion is that the reed is knocked out of position when the shuttle is trapped in the shed, as an alternative to the shuttle being forced through the warp, breaking down some portion of the threads, which in many instances would be equal to the length of the shuttle.

The reed is held in position by fitting the top rib to the groove cut in the hand tree; and at the bottom by the angle plate J. This extends the full width of the reed,

and is supported by the arms K fixed to the rod L. Easy contact is maintained between the angle plate and the bottom rib of the reed, during the forward movement of the going part, by means of two spiral springs M. If the shuttle is in the shed at this time the angle plate yields to the pressure and allows the reed to swing backwards out of position. At the same time the rod L is tilted, lifting the finger N to engage with the rack lever O. The latter being connected to the pistol lever, releases the starting handle and so stops the loom. To prevent the reed being knocked out of position by the force of the beat-up, two projections P, fixed to the rod L, are set to pass underneath the frogs Q, which are bolted to the front of the breast beam, thereby locking the reed in position to give a firm beat-up to the weft. To keep the reed from vibrating during the passage of the shuttle, the rod L is provided with a short arm carrying an anti-friction pulley R. This engages with the flat spring S and applies extra pressure to the bottom rib of the slay through the medium of the angle plate J and the arms K.

The successful working of this type of motion depends on careful setting and adjustment of the various parts, as may be required by the class of fabric to be woven. The length of the frogs Q must be adjusted to meet the fingers P according to the resistance offered to the slay whilst pushing the weft into position. This will vary with the fineness of the setting of the warp and the quality of the warp yarn. The reed should be fixed so as to be easily displaced if the shuttle is trapped in the shed. The finger N must be set to engage with the rack lever in order to dislodge the starting handle, and bring the brake motion into operation in order to stop the loom as quickly as possible.

Fast Reed Motion.—This style of motion is employed on looms weaving the heavier builds of cloth, in which

the resistance to the reed during its forward motion is excessive, and therefore requires the various parts to be very rigid at the beat-up. As the name implies, the reed is secured firmly in position between the hand-tree A and the groove cut in the going part to receive the lower rib of the reed. To protect the warp from breakage when the shuttle is trapped in the shed, the going part must be brought to a stop before any pressure is applied on the shuttle, which would result in the warp being severely damaged. The manner in which this is effected is illustrated in Fig. 59. Fixed in front or below the going part is a stop-rod B. This is provided with two stout blades C, usually welded to the stop-rod. At each end of the rod is secured a finger D, which is kept in contact with the shuttle box swell E by means of a spring; the curved portion or belly of the swell projects into the box for a short distance. Knocking-off frogs F are provided, these being placed below the breast beam, with which the protector blades C engage if there is no shuttle in the box. When the shuttle enters the box the swell is forced outwards, and with it the finger D; this tilts the stop-rod and lowers the protector blades, which miss the frogs and so allow the going part to work forward. If the shuttle fails to reach the box, the swell is not forced outwards, consequently the protector blades strike the frogs, which arrest the going part in its forward movement, bringing it to an abrupt stop. Suitable connections are made between the outer end of the frogs and the starting lever G to transfer the belt on to the loose pulley. In order to reduce the vibration and strain on the various parts of the loom when knocking-off takes place, strong springs H are employed which serve as cushions for the frogs F.

With faulty setting undue knocking-off will take place, and as a result breakages of the loom parts will be frequent. To reduce knocking-off to a minimum the picking motion

must be kept in good working order, and the protector motion set correctly. The chief causes of the latter defect are: (*a*) One or both of the fingers D not touching the box swell; (*b*) the box-swell pins being worn down; (*c*) the swell not projecting far enough into the box; and (*d*) too much vibration of the protector blades when the shuttle enters the box. The effect of the above defects will result in the protector blade engaging with the frogs from time to time, so that the respective parts should be

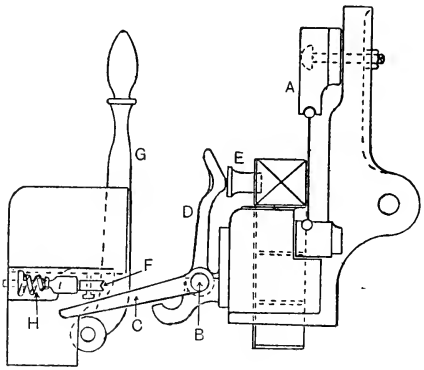


FIG. 59.

set to allow of the blades being kept well clear of the frogs with the shuttle in the box. Considerable difficulty is occasionally experienced in rising and drop box looms by reason of the curve on the box swells not being in the same relative position on each. If to this condition is added some slight difference in the size of the respective shuttles, which are run into various boxes during one repeat of the wefting plan, occasional knocking-off will result. A further and more serious defect in the working is experienced when one of the blades engages with its respective frog, whilst the other may clear when knocking-

off takes place. This is chiefly due to the stop-rod being twisted, or it may be due to the going part not working squarely throughout its stroke. In any case, this defect should receive immediate attention from the tuner, or serious results, chiefly twisting of the lay or breakage of the lay swords, will ensue.

WARP STOP-MOTION.—The function of this motion is to stop the loom when a warp thread breaks. This accessory to the power-loom is one to which considerable attention has been directed during recent years. This feature is no doubt largely due to the increasing development of automatic weft-replenishing mechanisms. Until recently warp stop-motions have been chiefly confined to those branches of the weaving industry in which a number of looms are under the supervision of one weaver —*e.g.*, looms employed in weaving such goods as silk and cotton umbrella cloths, Madras muslin and harness and leno fabrics, where the breakage of a warp end has to be repaired prior to finishing; if such goods contain a number of warp floats they are classed as seconds. A brief consideration of warp stop-motions discloses a multiplicity of parts, and also their somewhat delicate, if not intricate, construction. These factors, accompanied by the increased duties of the tuner attendant upon their adoption, are features which have to some extent retarded their initiatory stages. The tendency to the introduction of these accessories to the power-loom does not appear to be such as to warrant any prediction that they will become general at an early date, or even that they are absolutely essential on all classes of looms, although for certain looms they may eventually become more generally adopted. The main advantage which is to be derived from their application is in the production of a more perfectly woven piece, rather than in any increase in loom production.

There are two classes of these motions—the " mechanical " and the " electrical " warp stop-motion. A type of the former class consisted of a porcupine brush roller, placed immediately above the back-rest in such a position as to exercise a slight brushing action on the warp. The least resistance to the roller being sufficient to stop its rotation, additional mechanism, which received indication from the rotation or stoppage of the roller, was employed for stopping the loom. With the continuous motion of the roller the loom continues to run; when one or more of the warp threads break, they are brushed out from among the tight threads, and speedily picked up by the brush roller. The warp thread being fastened at the warp beam, directly it is drawn tight the stoppage of the roller is caused, giving indication to the mechanism employed for stopping the loom by shipping the starting lever out of the retaining notch.

Another type of mechanical motion consists of the application of a special indicator attached to each warp thread. This is illustrated in Fig. 60. The droppers A rest on the warp threads B as shown. Two rows of droppers admit of 100 per inch being employed. A trough C is fixed between the back-rest and the healds, over which fit the forked opening of the droppers. When a warp thread breaks, the dropper falls and allows its forked end to project below the bottom of the trough. This results in the feeler bar D, which is made to oscillate by suitable mechanism operated from the low shaft, being tilted from its normal position; and the feeler bar D being connected to the starting lever, knocks it out of the retaining notch and so stops the loom. It is claimed that this motion is suitable for any counts of yarn, different weights of droppers being supplied to suit yarns ranging from fine silk to thick heavy yarns of various materials.

Electrical Warp Stop-motion.—In this class of motion a weak electric current is employed. The current serves as the indicating medium between the warp thread and the mechanism employed for displacing the starting lever. In the mechanical type of motion a certain amount of vibration and shock is transmitted to the various parts, by reason of the mechanically actuated feeler bar being brought to an abrupt stop. For the electrically controlled mechanism it is claimed that the connection between the warp thread and the starting lever is rendered more gentle and sensitive in its action.

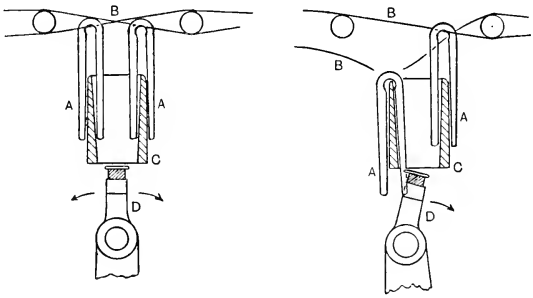


Fig. 60.

A type of this motion is illustrated in Fig. 61, and consists in the application of a spring wire A to act as detector, one such wire being employed to serve for every two threads. The wires are passed between the warp threads in the lease in such a way as to prevent their touching one of the lease rods B as shown. With the breakage of one or other of any pair of threads, the respective detector springs back to touch the contact bar C on the lease rod B. The result of this is to close the electric circuit between the brass fittings D in the bar tree E, which supports the spring wires A, and give indication to a small electro-mechanical motion which

displaces the starting handle of the loom. The current to operate the mechanism is derived from two dry cells, suitably applied to each loom, or in a complete installation it may be derived from a small dynamo, from which it is conveyed to the looms by suitably protected wires, to prevent the possibility of fire by spark or fusing.

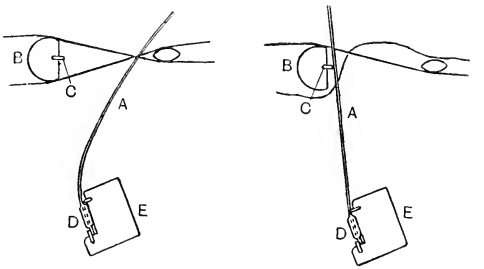


FIG. 61.

TEMPLES.—Temples are used to hold out the fabric during weaving to the width that the warp is set in the reed; and to enable the selvages better to resist the pull or drag of the weft, and consequently prevent excessive shrinkage weft-way of the cloth. There are various causes which tend to make a fabric shrink in width immediately it is drawn forward and released from the distending influence of the slay and temples—*e.g.*, the nature and quality of the weft yarns, the relative counts of the warp and weft yarns, the difference in the tension on the warp and weft during weaving, and the structure of the fabric—*i.e.*, the plan of interlacing.

Obviously, weft yarns possessing good elastic properties when employed for weft will shrink more than yarns which do not possess the same degree of elasticity. When the warp yarn is thicker and stronger than the weft yarn, the latter will be deflected more than the warp, providing the weave is composed of some regular order of interlac-

ing, as in a plain twill or hopsack weave shown at A and B, Fig. 62. With the warp and the weft yarns equal in counts and quality, the tension to be necessarily placed on the warp during weaving, being in excess of the tension on the weft, will impart a greater degree of deflection to the weft threads. The plan of interlacing the

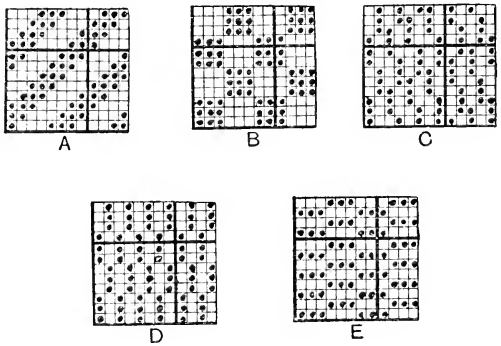


FIG. 62.

warp and the weft is a factor which influences to a considerable degree the amount of shrinkage warp-way or weft-way of a fabric. A good example of this is shown when weaving warp and weft cords. Taking the weaves given at D and E, which are warp and weft cords respectively, it will be noticed that in the weave D there would be three picks in the same shed; these would form themselves into one thick thread, and resist any deflection due to the increased tension on the warp. The picks would lie perfectly straight in the cloth, but the warp would be subject to excessive bending and corresponding take-up. The conditions would be reversed with the weft cord weave E, as here the warp threads work together in groups of three, and would therefore resist deflection by the weft, which would shrink or take up considerably.

The following particulars will further help to illustrate this feature. The plans shown at Fig. 62 were each woven in the same warp, half a yard of cloth being woven to each plan, a space of two inches of warp being left on each in order to allow the separate cloths to shrink freely.

Warp: 2/48's Botany worsted, 21 reed 4's.
Width in reed, 32in. inside lists.

Weave A,	woven with	2/48's,	84 picks per inch ;	width out of loom,	30in
,, B,	,,	,,	,,	,,	,,	30in.
,, C,	,,	,,	,,	,,	,,	31in.
,, D,	,,	,,	,,	,,	,,	32in.
,, E,	,,	1/48's	,,	,,	,,	28½in.

TYPES OF TEMPLES.—There are many different types of temples employed—barrel, star and roller temples. In the former type a barrel composed of spiked rings and plain discs is employed over which is fitted the temple cap, the piece being held firmly between the semi-circular grip of the temple cap and the spiked rings. The difference in the types of barrel temples consists in the length and shape of the barrel and in the number of the spiked rings employed in each. The barrel may be up to five inches in length, and fitted with inclined spiked rings throughout, or such a barrel may contain five spiked rings to engage with the list of the piece, the remainder being plain or rubber rings. This type is specially adapted for a variety of fabrics, the hold on the cloth being very effective.

Another type of this temple is made with the barrel tapered, which holds the selvage very firmly, but gradually diminishes its grip on the piece towards the end of the barrel. This type is specially useful for delicate fabrics tightly woven, in order to prevent the piece from splitting near to the end of the barrel. Another common type is known as the "star" temple. This consists of one or two metal rings about 2in. in diameter and ¼in. thick; the periphery being fitted with

rows of fine pins. The rings are supported in the temple brackets in a horizontal position, and take hold of the selvage of the cloth only. This type is specially suitable for fine fabrics which would be easily damaged by the spiked rings or marked by the temple cap.

ROLLER TEMPLES.—These are different from the former types and consist of a roller which runs to the full width of the piece, that is supported in a semicircular trough placed between the fell of the cloth and the breast beam. The surface of the roller is fluted at varying angles, in order to obtain a rough surface and so maintain a firmer grip of the fabric, which is in contact with half of the circumference of the roller. Such temples are employed for weaving light to medium fabrics, for which the spiked ring type of temple is altogether unsuitable, by reason of the spikes displacing and distorting the threads during weaving.

SUMMARY OF DEFECTS CAUSED BY TEMPLES.—The rings must be kept free from waste and grit, otherwise they cannot rotate freely, and the cloth is prevented from passing forward. The spikes may be damaged by being turned up at the point and formed into a small hook. These catch on to the fibres and threads of the fabric, and retard the forward movement of the piece until they tear themselves free, thus damaging the fabric. Many temple caps are made of brass; these quickly wear down when weaving some classes of goods, with the result that they fail to hold the piece out to the width in the slay, the warp threads being chafed down at the selvage. Occasionally the cap is indented or the barrel pin strained by reason of the shuttle being trapped in the shed, so that the piece is chafed while passing through the temple or kept from working forward freely. The temples may be set too near, so that the weft is cut between the temple and the reed wires, or the

wires become strained, causing reed marks in the piece. Temple marks are sometimes due to the cap being set too keen or close to the barrel, which in some fabrics leaves the impression of the cap when the loom is left standing any length of time; such defects are usually more pronounced and developed during finishing. Defective beaming of the warp—*i.e.*, tight or slack sections at the lists — is a common cause of the temples not being able to hold the piece effectively during weaving.

SELVAGES.—With the object of facilitating the operation of weaving and the subsequent processes of manufacture, it is customary to put a selvage on each side of piece-goods. Although that portion of the piece of cloth formed by the selvages is not intended to be utilized in the made-up garment, they may be considered as essential from an economical standpoint. It is important that suitable yarns should be employed for the purpose, this being a factor which very largely affects the weaving operation. Selvages are very desirable in those woven fabrics which are submitted to the operation of drying, after scouring, etc., on the tentering machine, as such a process results in the edges or selvages of the piece being rendered worthless. Badly-formed selvages detract from the value of the piece; on the other hand, a well-woven selvage always adds to the general appearance, and gives enhanced value to the finished fabric.

The large diversity of cloths manufactured results in a variety of selvages being used. Worsted cloths woven in the grey to be piece-dyed may have the selvage made of the same count and quality of yarn as that used for the warp, but with one or two cotton threads run in from half to three-quarters of an inch from the edge to form the selvage. Fancy worsteds are usually made with a solid coloured selvage of white or black yarns. White selvages have the disadvantage of showing up any irre-

gularity of weaving or other defect. When black or other dark-coloured yarn is employed it is advisable to run one or two ends of some highly coloured yarn as a dividing line between the selvage threads and those of the warp.

Woollen fabrics have a greater variety of selvages than worsteds, including diversity of counts, quality and colour. Woollen warps made from single yarns generally require the yarn used for the selvages to be twofold, due to the single yarn not being sufficiently strong to withstand the strain and chafing to which they are subjected during weaving. Woollen cloths being submitted to severe treatment during the finishing processes, particularly in the scouring and milling operations, demand special attention in the selection of the yarn to be used for the selvages. If the yarn selected does not possess the same degree of felting property as the warp yarn, long or short lists will result. Without trespassing too far into the domain of the finisher, the general effect of this may be briefly stated, as there is to a certain extent something in common between the selection of unsuitable yarn and defective interlacing of the selvages during weaving. Either error may be the cause of short or long lists, which cockle the piece by allowing the centre of the cloth to run slack during the finishing processes, whilst the sides of the piece are held tight, and must necessarily bear all the drag. On the other hand, when the lists are too long the piece is held tight in the centre, and the sides of the cloth run slack. This results in a very unsatisfactory finish being obtained on the piece, the centre and the sides not receiving the same treatment in the subsequent finishing processes.

There are other defects in selvages for which the weaving operation is more directly responsible. Occasionally the weaver will alter the healding and the reeding of the selvage threads as a remedy for frequent breakages—

probably the effect of the selection of faulty yarns, the selvage threads being drawn two in a mail on the outside edge to give additional strength. With thick woollen yarns this is not advisable, as the lists have then a tendency to curl, and may readily mill fast to the fabric if subjected to too much milling. When the threads are drawn double in this way, the list is increased in bulk, which retards the various subsequent processes, and produces " listed pieces "—*i.e.*, lack of finish at the sides.

Many pieces are spoiled by reason of one list being badly woven while the other may be perfect. This may be due to various causes. An imperfectly formed shed will result in one or both the lists possessing a ragged appearance. When the heald shafts are not adjusted correctly, some of the threads will either hang slack in the shed or be drawn excessively tight; this prevents the weft and the selvage threads from being drawn compactly together.

Uneven tensioning of the weft in the shuttles will produce an unsatisfactory list. In a piece woven with two or more shuttles running pick and pick, or two and two, and the weaver using one or two change shuttles, it is possible for the weft to be more heavily tensioned in one shuttle than in another; usually this is the result of the shuttle peg being set too low, so that the weft cannot pass freely off the bobbin. The effect of this would be to draw the lists tighter each time that particular shuttle was running, which would show down the list of the piece for a distance equal to the weaving length of the yarn on the bobbin. Such a defect may be the cause of the piece working out of the temples during weaving, and is a frequent cause of a variation in the width of the finished fabric. Cloths woven with two shuttles are liable to have a defective list on one side of the piece only. When the shuttles are started from the same side of the loom, the

tension on one selvage due to the drag on the weft will be greater than on the other. This defect is accentuated when the shuttles start from that side of the loom where the eyelet of the shuttle, when at rest in the box, is nearest to the picker.

When weaving with two or more shuttles on even picking, they should not be allowed to run so that the weft in each is spent and run off at the same time. It is understood that the drag on the weft increases as the bobbin empties, and the longer the bobbins or cops, the greater the difference in the drag between a full and nearly spent bobbin. Take, for illustration, the weaving of low woollens. The tendency during late years has been to increase the bobbins in length, and by this means obtain an increase in the number of yards on each bobbin so as to reduce shuttle changing. When very long bobbins are used it will readily be seen to what extent the drag on the selvage will vary from the full to the empty bobbin. Under such conditions the weft in the shuttles should not be allowed to run off at the same time, but arranged so that when one bobbin is full the other is half spent. By this means the drag on the selvages is kept more uniform, and better woven lists are produced.

Selvage Motions.—Frequently the selvages are required to be woven differently from the body of the cloth. Many warp-faced cloths necessitate a plain or weft-faced selvage to prevent them from curling. To produce such selvages on the piece extra heald shafts, known as skeletons, are sometimes employed, these being operated by means of special tappets or from spare jack levers in dobby looms. There are, however, many devices known to the tuner by which plain and other selvages can be produced without the aid of special heald shafts. The following are examples of a few of those generally employed:

The selvage threads on a cloth made with the prunella warp twill, woven back up as shown at A in Fig. 63, may be interlaced as shown at A^1. The odd threads in the selvage are drawn between the heald bands above the heald eye on the second and third shafts, and not through the eyelet in the ordinary way; the even threads are drawn through the eyelets of the first heald shaft. The draft for the threads in the warp is shown in dots, and the draft for the selvage in crosses. The effect of this arrangement is to produce a selvage with two picks of weft in the same shed, and one pick of weft in the alternate shed. To draw down those selvage threads which are passed between the bands on the second and third shafts, a selvage hook is employed, which is hooked on to these threads, and suitably weighted to draw them down to their bottom position—*i.e.*, on a level with the shuttle race every third pick, when the even threads are lifted by the first heald shaft.

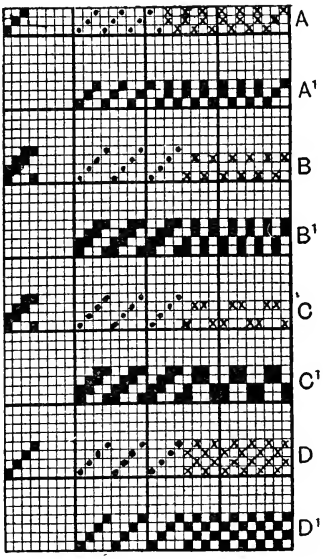


FIG. 63.

When such a selvage is produced on a fabric to be woven with one shuttle, it is necessary to draw the last three threads of the selvage through the eyelets of the healds, one on each shaft, to prevent the weft from being

drawn back through the selvage up to the warp threads, where the two picks are put into the same shed, or as an alternative method to fix up a catch thread.

The draft B shows a method of healding the selvage threads to obtain two picks in each of two different sheds, when the weave for the piece is the $\frac{2}{2}$ twill. The order of interlacing is given at B[1]. To prevent the weft from drawing back through the selvage, if woven with one shuttle, the healding of the threads at each side of the piece must be so arranged as to cross on the weft. This can be done by drawing the threads at one side of the piece on the first and third heald shafts, and those on the other side on the second and fourth shafts.

By a slight modification of this principle a selvage may be woven with two ends and two picks working together, forming a hopsack or mat weave, the plan of the cloth remaining $\frac{2}{2}$ twill. This is illustrated at the draft C, which indicates two threads drawn through separate healds on the same shaft; these should be split in the reed to prevent them rolling together, the order of interlacing being as shown at C[1].

To obtain a plain woven selvage on the $\frac{1}{3}$ twill, the odd threads would be drawn between the heald bands above the eyelets on the first and third shafts, and the even threads would be drawn between the heald bands on the second and fourth shafts, as shown in the draft plan D, the order of interlacing for the piece and selvage being as in D[1]. Selvage hooks, as in example A, would be necessary for each set of threads, to draw them down to the level of the shuttle race. This would necessitate one of the sets of threads in each selvage being left longer than the other at the commencement of the warp, to avoid the hook on one set when lifted to its highest point from coming in contact with the alternate set of threads. The effect of this would probably be to lift them off the

shuttle race, and produce a defective interlacing or render them liable to be broken with the passing shuttle.

CENTRE SELVAGES.—It is occasionally the practice to weave narrow pieces, termed splits, side by side in a broad loom, *e.g.*, worsted trouserings are frequently woven in this way. The warp pattern for the two pieces will be different; the wefting pattern and the yarn for each being the same, usually a solid colour. Pieces woven in this way require to have the list ends of the false selvage formed up the centre, one on each of the two narrow pieces, stitched. These threads are not stitched as tightly to the fabric as the outer lists, which are bound to the fabric by reason of the weft doubling back.

To prevent the centre selvages from fraying after the pieces are separated by cutting up the centre, usually after finishing, various methods are adopted. The object being to bind the outside threads on each of the selvages to the piece by twisting two or more threads round each other, and to interlace them with the weft in such a way as to produce as near as possible a perfect selvage.

When narrow pieces are regularly woven in a broad loom it is advisable to employ one of the several centre selvage motions obtainable for this purpose.

When such goods are only occasionally required there are a few contrivances by which the desired result can be obtained.

A very simple but effective method of stitching the centre selvage consists of an arrangement usually termed a " monkey," the crossing of the stitching thread being effected as shown in Fig. 64. A number of reeds are left empty between the two pieces, to allow of them being cut apart after finishing without in any way cutting the warp threads. If the ground of the fabric is working

plain, one or two of the warp threads A, according to their strength, are taken and passed through a guide wire B fixed behind the healds in such a position as to keep the threads on a level with the bottom shed line of warp. These threads are not passed through a heald but are stationary.

Next a crossing thread C of sufficient strength wound on to a special bobbin D, made with a grooved end for the purpose of braking, is suitably suspended behind

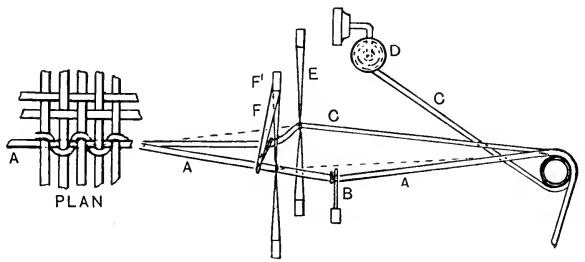


FIG. 64.

the loom. The crossing thread is first passed through a heald on the back shaft E; the stationary thread is drawn through the gear to the right of the heald E, which is shown lifted. The crossing thread C is next passed through a mail or bead attached by a loop of strong smooth cord F to the front shaft F^1, which is shown depressed.

The loop F is long enough to allow it to be drawn under the stationary thread and lifted up along with the crossing thread C to half the depth of the shed by the back shaft E. On the next pick the crossing thread would be drawn under the stationary thread, and lifted up the other side by the first heald to a height equal to half the depth of the shed. The stationary thread is

always under the weft, but is stitched to the selvage by reason of the crossing thread being lifted up on each side alternately and interlacing with the weft as shown in plan, Fig. 64.

The above arrangement is capable of application to a cloth weaving 2-and-2-twill. The crossing thread is operated by the first and third heald shafts, as these have a reciprocal motion and would stitch the crossing thread round the stationary thread once in every two picks.

The disadvantages of this method are twofold. First, the crossing thread, only forming a shed equal to half of the shed proper, requires careful adjustment to ensure perfect interlacing with the weft. Second, the crossing thread and the loop heald are subject to severe chafing and quickly wear out. When either of the threads or the loop heald breaks the selvage weaves forward unstitched.

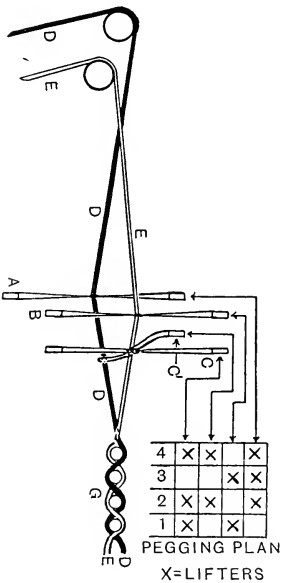


FIG. 65.

DOUP HEALD.—A further method occasionally employed for stitching the selvages on narrow webbings when woven in a broad loom is illustrated in Fig. 65. The principle consists in the application of a doup heald, such as is employed in the production of leno and cross warp effects. Two ordinary healds, A and B, are employed in addition to the doup heald, which consists of the heald C and the half heald C^1. The

crossing threads D are all put on to a spare beam or light roller.

The crossing thread is first drawn through the heald of the shaft A, then passed through the doup eyelet formed by the heald loop C^1, being interlaced with the mail or eyelet of the heald C. This is so arranged as to allow the loop C^1 to slide through the mail of C, when the crossing thread D is drawn down by the heald shaft A to the right of the thread E as shown in Fig. 65. The crossing thread is drawn down on the alternate or left side of E by the doup C and C^1.

The method of working is further illustrated by the pegging plan of the figure.

The first pick of the plan gives the position of the healds and threads as shown.

The second pick indicates for the next change as follows: The heald A, the doup C and C^1 and the thread D are lifted, whilst the heald B and the thread E are down.

The third pick indicates the healds A and B lifted, also both the threads D and E, but the doup heald C and C^1 is down, therefore the thread D is drawn down on the left side of E and across it. Owing to the thread D being lifted by the heald A, but depressed by the doup heald C and C^1, it is essential to slacken the thread D to facilitate the crossing. This is usually accomplished by drawing the back-rest forward by some mechanical contrivance, *e.g.*, this may be performed by means of a spare jack in the dobby.

The fourth pick is like the second—the crossing thread is lifted, the thread E being depressed.

The manner in which the crossing thread interlaces with the picks is shown at G. From this it will be observed that the threads D and E work plain, also cross and re-cross every two picks.

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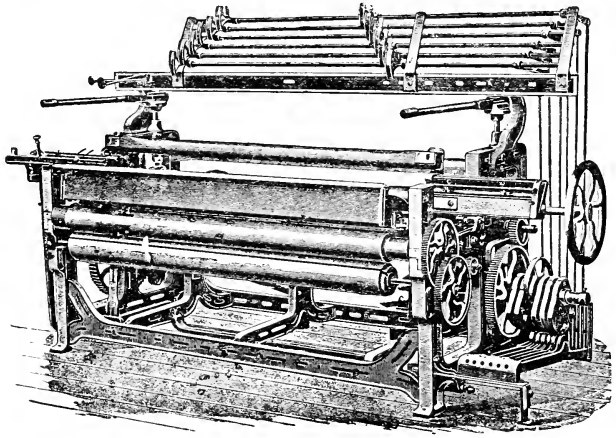

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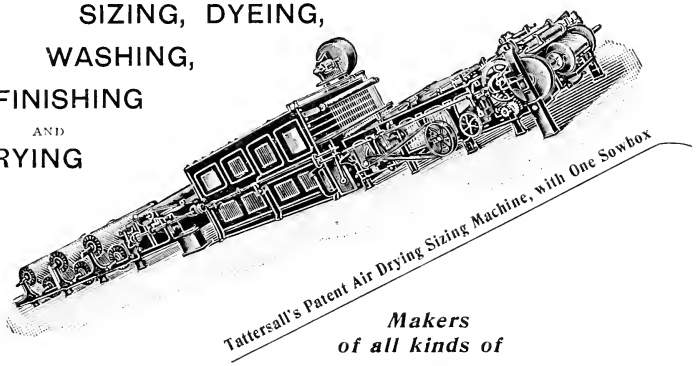

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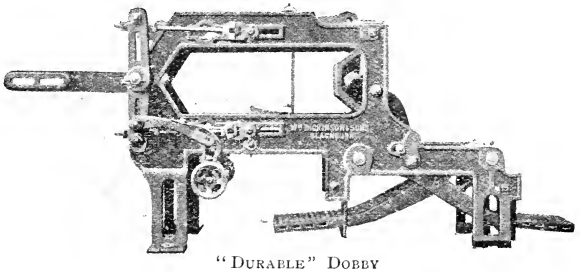

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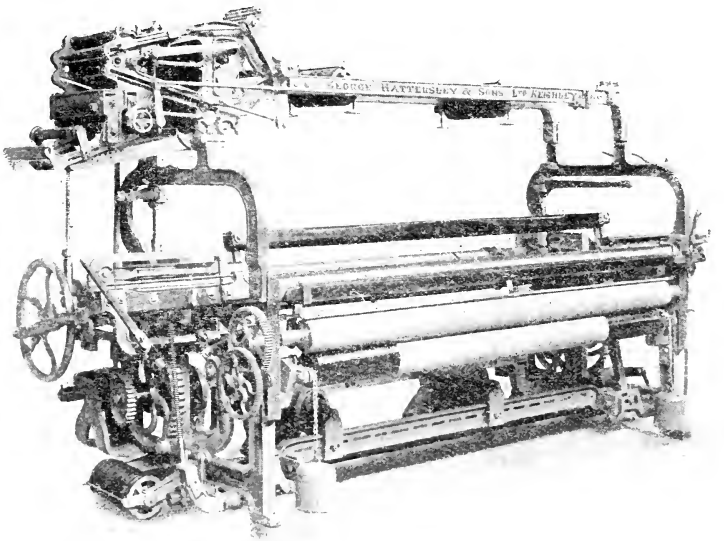

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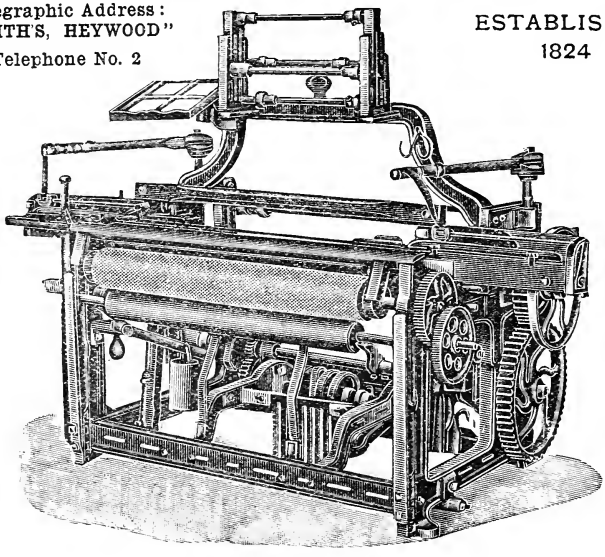

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